NATURE

No. 4491 SATURDAY, NOVEMBER 26, 1955 Vol. 176

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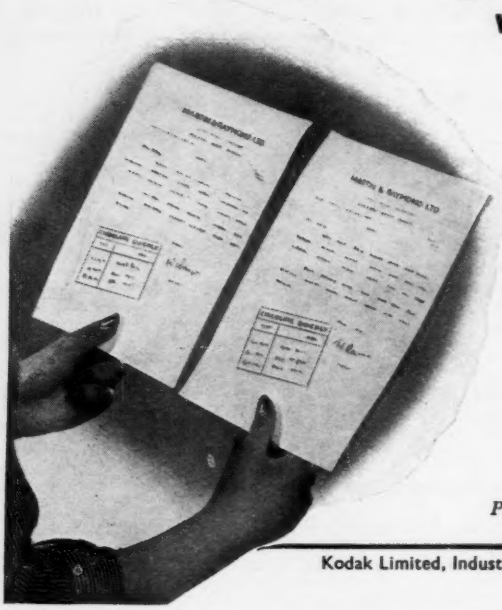

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THE SPIRIT OF SERVICE AND THE WELFARE STATE

"INDIVIDUALISM," wrote Lord Keynes, "if it can be purged of its defects and its abuses, is the best safeguard of personal liberty in the sense that, compared with any other system, it greatly widens the field for the exercise of personal choice. It is also the best safeguard of the variety of life, which emerges precisely from this extended field of personal choice and the loss of which is the greatest of all the losses of the homogeneous or totalitarian state. For this variety preserves the traditions which embody the most secure and successful choices of former generations; it colours the present with the diversification of its fancy; and being the handmaid of experiment as well as of tradition and of fancy, it is the most powerful instrument to better the future."

Lady Morris has set out in her book, "Voluntary Organisations and Social Progress"*, to examine the part played in social progress in Britain by the voluntary bodies. The book is less detailed than Lord Beveridge's survey, "Voluntary Action", and one misses the vivid vignettes with which, in his 'chapter on pioneers', Lord Beveridge displays the philanthropic motive in action; nevertheless, Lady Morris sometimes probes further back into history, for example, when discussing political movements; and in touching on education and the churches, she deals with aspects Lord Beveridge largely ignores. Apart from occasionally bringing a closer and more personal touch into the discussion of particular problems than Lord Beveridge did, the seven years that have passed since Lord Beveridge's book was published enable Lady Morris to testify more emphatically to the continuing value of the voluntary association in the Social Welfare State.

Her book, in fact, is essentially an exposition of the thesis Lord Keynes enunciated in the words already quoted, and passage after passage in Lady Morris's book recall those words to mind. In philanthropy, in politics, in associations of working men in education, in the churches and in voluntary social service, she traces progress to the vision and determination of individual men and women, sometimes as lonely pioneers, but generally as leaders and members of groups, who were prepared to accept responsibility and to devote time and energy to achieving social progress by means of democratic associations outside the machinery of government. Believing that a society in which each person has the opportunity of leading the good life can only be achieved if the proper spheres of action of State and individual are discovered and respected, she is not content to display the past and the present, but proceeds to ask the leading questions which determine the realization of such a society.

What are the proper spheres of action for State and individual if such a society is to be possible? Does the division of function now being evolved in Britain conduce to the good life? And, if it is true, as Lady Morris's book, like Lord Beveridge's report, indicates, that social progress in the past has been largely due to the activities of individuals and groups outside the organization of government, what will happen if the parts played by statutory and voluntary action continue to change in the way in which they appear to be doing now? These are the questions that should be under examination, and although Lady Morris does not discuss them in any detail, at least in her introduction and in the second part of her survey of voluntary social service in the twentieth century, she indicates where the answers are to be sought. She also notes some of the factors that require further study, and directions in which our ideas should turn in considering the structure of society and the needs to be met by State action and those which should be left to the action of the individual or the voluntary group independent of statutory authority.

By and large, these questions are not being publicly discussed in the way their importance demands. Particular issues in which they are involved are apt to be determined in the light of partisan debate or the *ad hoc* circumstances rather than with regard to the long-term effects and their bearing on the intrinsic health of a democratic society. The warning notes sounded so clearly by Lord Beveridge as to the need to keep room, opportunity and encouragement for voluntary action in seeking new ways of social advance, for command of resources for social purposes being in the hands of some body other than the Government or the State, or, again, the need to make and keep something other than the pursuit of gain as the dominant force in society, have largely been ignored. Little has yet been done to influence directly in this way, not a few leaders, but the mass of the people; and democracy has still to show that, in discarding the inequalities, it can learn the virtues, of aristocracy.

For that reason alone, however much the present book by Lady Morris overlaps Lord Beveridge's report, the appearance of a fresh statement of the vital importance of voluntary effort, free to experiment, and endowed with the material resources which make effective service possible, would be welcome. Her book, however, bears the stamp of her own personality, and the arguments with which she challenges fresh thought on these vital issues are no re-statement but flow freely from the fountain of her own experience. Her story of the part voluntary groups have played in building the Britain of to-day, and in the achievement of reform and the elimination of injustice, is told in a way which shows clearly not merely that the opportunities for such voluntary effort persist into the welfare State, but also that without the help of such voluntary groups the individual and society will be the poorer, and even the security of the State endangered.

The survival of a society which provides its members with the opportunity to lead the good life depends, writes Lady Morris, "on there being enough people in it who understand what is at stake, who

* "Voluntary Organisations and Social Progress". By Lady Morris. Pp. 224. (London: Victor Gollancz, Ltd., 1955.) 18s. net.

mind what happens to it, and who are prepared to take action in its service, not only by defending it in war but by striving in war and in peace for social progress". The work will, however, only be done successfully if the voluntary bodies continually re-examine their position, to see what aims and methods are demanded by actual needs and conditions; and Lady Morris pointedly directs this remark at the political parties and the trade union and co-operative movements, no less than at those engaged in social service in the more limited sense. All kinds of voluntary bodies need to adjust themselves continually to changing conditions if they are to render effective service and avoid setting up disruptive strains in the society in which they exist; and one of the great needs of to-day is not simply for self-examination of their functions and purpose by the voluntary bodies, but also for keen, unprejudiced thinking as to the limits of State action and the respective functions of voluntary and State effort.

There is, however, a second need, and perhaps an even graver danger. What is achieved in Great Britain through the voluntary bodies depends on there being enough people able and willing to give them the necessary time and energy. This is recognized by Lady Morris, and she rightly emphasizes that public spirit and the desire to work with a group for a chosen cause have persisted into the welfare State with at least some recognition that without personal effort that State may atrophy.

Women are now playing a much greater part in voluntary service and organization. In spite of home ties, married women have, during the past twenty-five years, come to the fore. It is, perhaps, significant in this connexion that the author of "Voluntary Organisations and Social Progress" is a woman. Another outstanding living example of a woman voluntary worker is Lady Petrie, wife of the historian, who is not only a member of the London County Council and councillor (and, at present, mayor) of a London borough, but has also become known far beyond the boundaries of her borough as an effective voluntary worker especially in such fields as hospital organization, public health, education, care of the aged, maternity and child welfare. It is certain, therefore, that though half a century ago we looked to the leisured classes for voluntary work, this is not the case to-day; yet all have more leisure at their disposal.

The voluntary services have, it is true, a problem in learning to use part-time help on an increasing scale; but the major problem is in cultivating the spirit of service among the new leisured thousands—a spirit which runs counter to the whole climate of the Welfare State as often expounded in political doctrine. They are faced, however, with an even graver problem. Lord Beveridge himself emphasized the vital importance of voluntary action being dependent on current giving rather than on endowments from the past or favours from the State, and emphasized the need for exploring new channels for the impulse of giving among the mass of the people. He asked, in writing of our need for a never-ending line of successors to the Webbs: "By what device will the society of the future be able to ensure that the spiritual successors of the Webbs will have their material resources for research, untrammelled by other duties, by orthodoxy or by prescription of topics?"

The point was put equally forcefully by Roger Wilson in the notes on the future of voluntary social work included among the "Evidence for Voluntary Action"; though, referring to the drying-up of traditional sources of money, he expresses the opinion that of the three problems—the use of the part-time volunteer in official administration, the finding of money, and the finding of time—the finding of time is the most important. What needs to be emphasized, however, is that the problem of money for voluntary work, and equally that of time, is largely the resultant of Government policy. The difficulties to which Lord Beveridge and Lady Morris direct attention are not the result of blind forces but to some extent are due to factors within our own control.

This is a matter for the scientist who is concerned as to the future of the independent research institution, whether engaged in the physical, the biological or the social sciences, with the resources available for such institutions and with the autonomy of the universities in view of their increasing dependence on State support (and Lady Morris in her chapter on education glances in passing at the independence of the universities and at the future of adult education). He may also turn to the challenging article in *Lloyds Bank Review* of October, in which Prof. L. Robbins asks some pertinent questions as to where the present taxation policy of Britain is leading us. Prof. Robbins's "Notes on Public Finance" range over a wide field, but their general interest, as well as their interest for the scientist, is derived not from the discussion of the detailed effects of the British system of taxing, but from the searching inquiry into the long-term effects of financial policy and the frank advocacy of its use to promote changes in the structure of society that are desirable. Prof. Robbins maintains that the operation of the present tax structure is not neutral, but that year by year it is pushing us relentlessly towards collectivism and property-less uniformity.

We are not here concerned with the details of Prof. Robbins's argument, or with the instances he chooses to illustrate it. Its relevance in the context of the future of voluntary effort, and of the independent institutions where the creative thought and inquiry upon which social and scientific advance alike depend can proceed unrestrained, is that he directs attention to a political formative factor in our society which is not being used as it might be. If, for example, our ideal is a property-owning democracy, we are allowing our tax system to work the other way; nor are we using it to facilitate the solution to many social and industrial problems which might be possible if instead of profit-sharing we used tax policy to encourage industry to make its workers equity owners on a large scale.

What is important is that preconceived ideas are challenged, and an attitude to the death duties and to the present tax on marriage advocated which is

realistic and related to the kind of State desired, rather than to particular political doctrines or short-term Treasury dictates. Here, as in our attitude to the future of voluntary action, we are faced with a challenge to thought. If we really wish to build the good society, to safeguard the institutions which provide the growing-points and starting-points of creative advance in whatever field, we are taken back to this imperative and inescapable duty of re-examining, and where necessary re-shaping, the institutions which at present minister to our needs, so that they serve our purposes more effectively in the conditions of to-day. We need to be clear as to what those purposes are, and we need to be sure, as Prof. Robbins reminds us, that we are not allowing factors under our control, by neglect or default, to carry us further from our goal. Lady Morris's book and Prof. Robbins's notes on public finance have this in common, that they challenge us to such examination and to constructive thought. They can equally remind us of Lord Beveridge's words: "Emphasis on duty rather than assertion of rights presents itself to-day as the condition on which alone humanity can resume the progress in civilization which has been interrupted by two world wars and which remains halted by their consequences". Much has happened in the seven years since Lord Beveridge wrote those words to attest their truth; and if Lady Morris's book may be expected to engage more particularly the attention of professional associations of scientists, Prof. Robbins's article will at least remind them that even fiscal policy can be such as to foster rather than to discourage initiative, enterprise and the free intercourse of minds and exchange of ideas, which are the root of creative activity and the advancement of knowledge in every field.

THE PERSONALITY OF A GENIUS

Darwin Revalued

By Sir Arthur Keith. Pp. x+294+5 plates. (London: C. A. Watts and Co., Ltd., 1955.) 25*s*. net.

THE title of this book by the late Sir Arthur Keith is, perhaps, something of a misnomer. He does not attempt any major revaluation of Darwin's scientific work but, rather, is concerned in the main with Darwin the man, with the events and tempo of his life and his habits of mind and body. Again it is not so much a revaluation of these that we are offered, but rather a condensation of the enormous mass of data which Darwin left behind him in the form of letters and other writings. Few lives are better documented; the very richness of the sources makes it a laborious task to extract out of them a fair and complete view. Sir Arthur writes: "I have tried as far as possible to make Darwin tell the story of his life in his own words, while I am merely playing the part of a 'cinema-operator' ".

I think most readers will agree that this endeavour has been very successful. But what an astonishing and complex character Darwin was, and how difficult to form a just picture of him! Towering above everything else is his majestic grandeur as a scientist and as a thinker who changed the whole of man's view of his position in the universe. But at the same time his weaknesses as a human being are very obvious. He remained a devoted parent, and a kindly and helpful colleague to his scientific contemporaries; but throughout most of his life, his devotion to natural history reached a pitch which can only be called obsessional. For the rest, he cut himself off from most social contacts, and from almost the whole non-scientific area of human interest—poetry, art, politics and, to a large extent, religion. Or perhaps one should say he was cut off, by a chronic digestive illness against which the only effective remedy seems to have been work, but which often left him too incapacitated even for that. It is Darwin, the pillar of Victorian achievement, rather than Proust, the recorder of Victorian society in decay, who is really the example of the invalid genius, whose intellectual life was passed on a sofa. But for all that, he possessed in full measure another solid Victorian virtue—he was an excellent man of business and managed his investments (largely in railways) so that at his death he left a very sizable fortune.

How did this character—physically tortured, one must suppose, by some psychosomatic trouble, and retaining an unruffled intellectual assurance at the expense of extreme concentration on observing the external world—grow out of the relatively straightforward and energetic young man we meet in the "Voyage of the Beagle", with his enjoyment of a dinner of freshly killed beef grilled at the campfire of the Gauchos on the Argentinian pampas? And what influence, if any, did the peculiar forces which must have been buried in Darwin's odd personality exert on his scientific theories, which, it must not be forgotten, carried with them consequences of the most profound importance for our philosophies both of society and of the individual? Sir Arthur Keith does not attempt to answer such questions, although he allows himself a few asides which touch on them. But he stage-manages the appearance before us of a historical personage of great magnitude and complexity, whose personality undoubtedly deserves much fuller study and discussion than has yet been given to it.

C. H. WADDINGTON

WEATHER OF THE TROPICS

Tropical Meteorology

By Herbert Riehl. Pp. x+392. (London: McGraw-Hill Publishing Company, Ltd., 1954.) 61*s*.

IT is not a little odd that text-books on general meteorology rarely make much reference to tropical meteorology (the hurricane or typhoon may be a notable exception) and even provide rather little in the way of theory which may be usefully applied to the weather and winds of tropical regions. Yet the tropics embrace almost a half of the earth's surface, contain a large number of its people, and have weather which differs notably in style from that of extra-tropical regions. The Second World War, with important theatres of operation in lower latitudes, brought home to many our humiliating ignorance of tropical meteorology and spurred some to a considerable effort of research on the subject. Accepting, for the moment, a purely utilitarian point of view, it is clearly to our interests to further the work then started; for it is within the tropics that solar energy is most freely available—if we can make effective use of it—and, not unrelated, that the most

substantial increase in world crops could occur. That the tropics or, rather, the sub-tropics (±30° latitude), which form the more natural meteorological boundaries, contain both the driest and wettest latitudes of the world is not the least part of the practical challenge, and this can scarcely be met until we can describe and understand more fully than at present the atmospheric processes within those latitudes. The problems are much more than those of geography, though geography is inevitably involved.

Tropical meteorology suggests to many, I suppose, trade winds and monsoons, the former blowing with great and, in an earlier day, useful regularity, though with seasonal variations, and the latter with well-defined onset and appropriate precipitation in their season. The picture is not wholly false; but the great irregularity of the incidence and amount of rainfall in both systems, day to day, and year by year, indicates that the weather is not to be explained wholly or even largely in terms of climate. In other words, it is the variations about the climatic norm as well as the norm itself which demand inquiry in low as in temperate latitudes. Moreover, since the temperate and high latitudes rely ultimately for their winds and rain on a source of energy within the tropics, we must suppose that variations in the tropics are somehow reflected in extra-tropical weather and climate.

Prof. Herbert Riehl was one of the war-time workers who was impressed by the variability in tropical weather and who has made substantial contributions to its study. He has now written a book which, while giving due weight to the geography and climate, is most concerned to present a physically co-ordinated account of the whole sequence of weather in low latitudes. His book is thus descriptive and theoretical, but only partly deductive; more description and more theory are required before a satisfactory deductive treatment will be possible. The skill with which he has combined description with theory is masterly, so that reading is a great joy as well as a good discipline.

There are twelve chapters, in which spatial and temporal variations in pressure, wind, temperature and rainfall are first presented and discussed, the accent being on climate. Due regard is paid to vertical variation where appropriate, for although upper-air stations are still woefully sparse in the tropics, the War and subsequent years have added considerably to knowledge of conditions aloft. Diurnal and orographic effects are treated next, and then follows a most successful chapter on convection. Its terms extend well beyond the tropics and should be read by any interested in this field; its relevance to the book is, however, unquestionable, since convection is so important a part of the motion of the tropical atmosphere. A rather irrelevant chapter on the physics of tropical rain is then interpolated from another hand, and the remainder of the book (six chapters) is devoted to synoptic disturbances and the general circulation. The treatment is unquestionably successful, both in description and in making the reader aware of how much may be explained on dynamical and thermodynamical grounds and of how much for the moment may not. The author's own researches on waves in the Easterlies guarantee successful treatment of that subject, and I found the chapter on hurricanes particularly cogent writing.

The book is so successful on the whole that one major criticism, related to the author's treatment of hydrodynamical problems, will not be misconstrued. While the book is addressed to a graduate in physics, the author has decided to avoid mathematical equations as far as possible—but not completely. This leads him to talk of unfamiliar concepts such as vorticity without the introductory formal treatment which shows how they arise in meteorological hydrodynamics, and to proceed in a few lines to a mathematical statement of the theorem of conservation of potential vortieity without allowing the reader to know quite how he got there. It is doubtful whether a subject like hydrodynamics, which is certainly difficult of simple exposition, and yet so important for the author's purposes, is to be apprehended by such methods—or by such 'wilful' remarks as "the current meets the *opposition* of the low-level maritime air" (my italics). Again, the author's interpretation of differential equations, in the interests presumably of simplicity, has a touch of eccentricity here and there and is likely to confuse more than clarify.

But this will prove to be an important book in the development of meteorology and is greatly to be welcomed. It is well produced, well referenced and well indexed, and the misprints, though rather numerous, are not serious. Its price is rather forbidding to most individuals who might hope to buy it from a sterling purse. P. A. Sheppard

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LETHAL FACTORS IN GENETICS

Letalfaktoren

In ihrer Bedeutung für Erbpathologie und Genphysiologie der Entwicklung. Von Prof. Ernst Hadorn. Pp. 388. (Stuttgart: Georg Thieme Verlag, 1955.) 39 D. marks.

LETHAL genes or chromosome rearrangements with lethal action are not essentially different from other genes or chromosome rearrangements. All genes and many chromosome rearrangements affect development, and whether this results in death before reproduction depends equally on the genes themselves as on the organization and living conditions of the individual in which they occur. A study of the action of lethal genes can therefore scarcely avoid dealing with questions of general gene physiology. In the present book, as shown by its subtitle, this aspect has been emphasized, and the result is a most valuable contribution to general developmental genetics.

The larger, and by far the most important, part of the book uses lethals for illustrating and analysing general principles of gene action. The examples range far and wide through the realm of living beings from bacteria to man, although the emphasis is on higher animals. Much of the material comes from the impressive work of Prof. Ernst Hadorn himself and his school. The chapter on the biochemical analysis of lethal development deals with a new and promising field in which the author has done pioneer work. Among the discussions of wider questions, three seem particularly interesting to me. The first deals with the value of phenocopy studies as tools for elucidating gene action. Prof. Hadorn's attitude is here mainly one of caution; he thinks it unlikely that these studies will shed much light on primary gene effects. The second concerns the specificity of gene action. In contrast to Grüneberg,

the author admits the possibility of true organ specificity caused by gene action on a field of differentiation or on the integrative processes which precede organ formation. The third is pleiotropy, of which a penetrating analysis is presented. Primary pleiotropy, that is, the existence of multifunctional genes, is considered as a possibility. Other types of intracellular or intercellular reaction chains that may lead to pleiotropism are illustrated diagrammatically. For one of these, namely, the selective activation of genes by the cytoplasm, Beale's work on *Paramecium* antigens might have been quoted as evidence. The terminology of pleiotropic mechanisms matches the subtlety of this analysis, and it leaves me wondering whether a simpler, though less precise, terminology might not be preferable. Some new terms, such as 'autophene' and 'allophene' for phenotypic traits that are determined respectively by the genes in the affected cells themselves or by genes in other cells, are useful and merit a place in the vocabulary of developmental genetics. For readers who are intimidated by the abundance of technical terms, a full glossary is provided.

The first third of the book treats more purely genetical questions, such as the detection of lethals, mutation-rates, and the frequency of chromosome rearrangements with lethal effect. These lucidly written chapters, although less stimulating and original than those dealing with gene action, should be very useful for the beginner in mutation work.

The clear writing and logical presentation make the work easy to follow and pleasant to read. It has been beautifully produced, and the paper does justice to the many excellent diagrams, most of them drawn by the author's son, which form a specially attractive feature. There is an extensive list of references. Altogether, this is an admirable book, interesting and stimulating for the experienced geneticist and yet simple and clear enough for a newcomer to the field of genetical research. One minor mistake may be corrected in the next edition: the hormone therapy against teleangiectasia, mentioned on p. 286, is used on heterozygotes, not on homozygotes which, as explained on p. 138, are probably inviable.

C. AUERBACH

THEORETICAL ORGANIC CHEMISTRY

Theoretical Principles of Organic Chemistry

By Prof. Walter Hückel. Vol. 1. (Translated from the corrected seventh German edition by Prof. F. H. Rathmann.) Pp. xi+904. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1955.) 77*s*. 6*d*.

THIS English version of Prof. Walter Hückel's text-book, which has been given a clear, if apparently at times rather literal, translation by Prof. F. H. Rathmann, will be of interest to all organic chemists. The topics considered in this first volume, after a preliminary chapter on valency, include stereochemistry, oxonium compounds and molecular complexes, compounds with abnormal valencies, tautomerism, intramolecular rearrangements, steric rearrangements, unsaturated compounds, aromatic compounds, and the course of chemical reactions. The material is dealt with largely in chronological order, from the point of view of the problems which arise directly from classical studies of organic reactions. Those aspects which require considerable knowledge of physical chemistry—particularly the relationships between constitution, physical properties and reaction velocities—have been deferred to the second volume.

Modern theories of organic chemistry derive some of their attraction from their power to enable, first, the correlation, within a consistent theoretical framework, of many of the at first sight diverse phenomena of organic chemistry, and secondly, the recognition of recurring patterns of behaviour, even though these may not always be quantitatively predictable. Not only do these theories rely on physical principles in discussing molecular properties and reactivities, but also they allow an extensive correlation of the physical properties of atoms and molecules with their chemical structures and reactivities. The impact on chemical theory of the ideas derivable from atomic and molecular spectroscopy, for example, has been very great, and the overlapping, in this kind of way, of pure chemistry, on one hand, and pure physics, on the other, is a striking and particularly happy feature of modern chemical thought.

The method adopted by Hückel suffers from the disadvantage that a considerable separation is made of the organic from the physical approach to the subject. Although the author himself has obviously such a thorough understanding of both aspects that he finds it necessary frequently to make references forward to more complete discussions which presumably will appear in Vol. 2, the result is still not entirely satisfactory.

Even within the adopted framework, considerable criticism is possible, particularly of the treatment of recent work. Many of the more significant advances of the past twenty years have been neglected, or are mentioned only in footnotes. The treatment of the Walden inversion is but one example of a limited recognition of recent advances. The rule is given that "the replacement of negative groups by anions gives a Walden inversion"; but it is stated that otherwise "for the greater portion of the yet known reaction processes, the riddle of the Walden inversion is not yet solved". Many would have considered that this was a conservative point of view even in 1938, when E. D. Hughes (*Trans. Farad. Soc.*, **34**, 213) discussed, in the course of a general survey of the Walden inversion, the effects of substituents in determining the steric course of unimolecular nucleophilic substitutions. To retain this attitude to-day, without even a passing reference to the development, by S. Winstein and his school as well as by British and by other American workers, of the stereochemical effects of substituents *beta-* to centres at which nucleophilic displacements occur, renders the whole discussion of this important aspect of aliphatic chemistry completely out of date.

Few authors, perhaps, succeed in putting the theoretical developments of their subject into completely proper historical perspective. As a source of references to the relevant experimental and theoretical contributions from the German schools of chemistry, this work is probably unexcelled. As a discussion of the phenomena of organic chemistry, and of the deductions which can logically be derived therefrom, it should be of some value to those prepared critically to compare this treatment with that preferred in other works. As a modern discussion of theoretical organic chemistry, it is disappointing.

P. B. D. DE LA MARE

An Introduction to the Theory of Seismology

By Prof. K. E. Bullen. Second edition. Pp. xv+296. (Cambridge: At the University Press, 1953.) 35*s*. net.

THE first edition of Prof. K. E. Bullen's "Theoretical Seismology" was so clearly and concisely written that within a short time it had become the accepted standard treatise on the subject. The only substantial point of criticism of that edition was the absence of references, evidently with the idea of brevity. This defect has been remedied in the second edition, which concludes with twenty pages of references to treatises and original papers, classified under chapters, or sections of chapters, instead of the more usual kind of reference to a specific sentence or phrase in the text. Actually, this method has the advantage of serving both as a list of references (with the name of the author of a paper as a sufficient connecting link) and as a bibliography for each subdivision of the subject.

The second edition follows the pagination of the first, but sentences and short paragraphs have been inserted which bring the book up to date. As examples mention may be made of the application by F. Birch of Murnaghan's theory of finite strain, and B. Gutenberg's discussions of Californian earthquakes (which have suggested the idea of 'low-velocity layers'). Prof. Bullen might well have enlarged on his own recent contributions to the theory of the structure of the Earth's interior; in fact, however, he does little more than mention his 'Model *B*', in which the coefficient of incompressibility is taken as a smooth function of the pressure p below the region *C*—that is, below about 1,000 km. An account is given of W. H. Ramsey's theory of phase transitions, in which the Earth and the terrestrial planets are assumed to have the same primitive chemical composition, with phase changes induced by pressure. Bullen has shown that the use of his Model *B* gives a closer fit with the data than does his Model *A*, as used by Ramsey.

Other additions are an account of the recent work of Jeffreys on the thicknesses of the continental layers, and a brief statement of Willmore's discussion of the observations made on the Heligoland explosion. The author is to be congratulated on the freedom from misprints and on the maintenance of the standard of conciseness despite the development of the subject.

R. Stoneley

Plant Climate and Irrigation

Edited by Sidney A. Searle. Pp. xi+155. (Chichester: Chichester Press, Ltd., 1954.) 20*s*.

THE title of this book is misleading; it suggests a work on the relation of plant growth to regional climates and the application of irrigation principles to all kinds of crops. In fact, the book refers almost exclusively to glasshouse crops and mainly to tomatoes.

As so often happens with symposia, the contributions by the different authors are very unequal in quality and value. Scientifically, the most valuable contribution is the chapter reviewing the measurement of soil moisture, since, apart from the contributor's own more extensive review published elsewhere, this information has not previously been collated. A large section of the book is a reprint of a thesis submitted for a higher degree and is, *ipso facto*, unsuitable for publication, in spite of the useful work described. Elsewhere there are some bad errors in plant physiology and a number of theories based on slender evidence. A chapter entitled "Growing in a Microclimate" turns out to be an *ex parte* argument in favour of a particular system of heating for glasshouses. In passing, it may be remarked that it is difficult to imagine how plants in a glasshouse would be considered as growing in anything other than a "microclimate"—a much overworked word at the present time.

The book is intended for the commercial grower; but in the reviewer's opinion it might well be misunderstood by such a reader if he were not scientifically trained and could sift the grain from the chaff.

R. H. Stoughton

Freshwater Microscopy

By W. J. Garnett. Pp. xii+300+50 plates. (London: Constable and Co., Ltd., 1953.) 30*s*. net.

THIS book is intended as a simple introduction to the microscopical study of the plants and animals of the fresh waters of Great Britain. It is written in a popular style and the author no doubt had the amateur microscopist mainly in mind when writing it; but it could be used also by students of biology at schools and universities. It can be recommended to anyone taking up this branch of study. Not very many species are dealt with, but the distinguishing characters of the selected organisms are given clearly, so that it should be possible to achieve at any rate an approximate identification of many of the common microscopic organisms of fresh water. Recognition will be greatly helped by the numerous photomicrographs, most of which are very characteristic of the living specimens.

The author makes quite a number of mistakes in matters of fact (as well as in spelling); but many who could easily correct the slips could not write nearly such a good book as this. It is obvious that the author has first-hand acquaintance with his subject and a lively interest in it, and he writes with infectious enthusiasm. He is essentially an observer of the living organism and its activities. The practical advice is on the whole good, though one regrets that he does not mention the valuable mounting media introduced by Amann.

John R. Baker

Cells and Societies

By Prof. John Tyler Bonner. Pp. iv+234+8 plates. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1955.) 25*s*. net.

IN this lucid and entertaining exposition, the author's central theme is that in animals and plants at all the levels of development in the scale of evolution, including that of man himself, a certain recurrent sameness can be discerned, in particular in such activities as the intake of food, reproduction and co-ordination; and this is demonstrably true whether we make an analysis of life processes in an animal society or in an individual unicellular organism. While the details of how these needs are met are endlessly varied in different groups and organisms, a scrutiny of the wide range of materials which the author discusses shows how general and pervasive are certain basic phenomena. Because of the simplicity and clarity of the exposition, and the effort that the author has made to formulate and discuss general ideas on life processes, this book can be commended both to the interested lay reader and to the student of biology.

C. W. W.

WEATHER FORECASTING: THE FUTURE OUTLOOK*

By Sir GRAHAM SUTTON, C.B.E., F.R.S.
Director of the Meteorological Office

THE profession of meteorology is concerned, among other things, with a branch of technology that is based upon the application of physical principles to an ancient and universal art. However, this article is confined to weather forecasting as practised by the professional meteorologist. In Britain everyone forecasts the weather every day, if only as a conversational gambit, and the mass of proverbial sayings, signs, saints' days and the like connected with the weather show the antiquity of this practice of observation and deduction. This traditional form of weather prediction is based on the belief that the state of the atmosphere in a limited region at any given instant is uniquely related to the weather afterwards experienced in the same region. Provided that the period of the forecast is kept short, this belief is largely justified, and in the days of sail the seaman, by watching the sky and the barometer, could often make reliable forecasts of coming storms. Much the same degree of 'weather wisdom' is shown by those who live in the country, in particular by shepherds and others whose work keeps them in the open for long periods.

Traditional weather lore has no conscious relation with physics. A few of the best-known signs and portents can be explained in terms of physical meteorology; but proverbial sayings are often entangled with superstition, and the majority, on close examination, have proved to be unreliable guides. This applies without exception to proverbs that attempt to forecast for long periods ahead. Thus the weather on St. Swithin's Day (July 15) bears no unique relation to rainfall during the next forty days, and I know of no popular belief that will help me to predict the nature of, say, the coming winter with any degree of assurance.

Scientific weather forecasting is the child of the electric telegraph. We can fix its date of birth in Britain with fair precision, for in 1859 the British Association, meeting in Aberdeen under the presidency of Prince Albert, decided to recommend that the Board of Trade should instruct its newly formed Meteorological Department to make use of telegraphy to warn ports of approaching storms. To-day we would not regard this as genuine forecasting, but rather as timely reporting. However, FitzRoy, the first director of the Meteorological Office, encouraged by Le Verrier of France, soon began to include prognostications in his warnings, and in 1861 he introduced the word 'forecast'. It is appropriate here to repeat FitzRoy's words concerning forecasts: "Prophecies and predictions they are not: the term forecast is strictly applicable to such an *opinion* as is the result of a scientific combination and calculation . . .". Soon after taking up my present post, I was moved to write a letter to *The Times* in much the same vein, reminding the readers of that newspaper that "the meteorologist is to be regarded more as an adviser than as a prophet".

FitzRoy's experiment—for it was scarcely more than that—did not find universal approval among men of science. This is scarcely to be wondered at, because for many years the whole matter of foretelling weather had been bedevilled by the almanac makers. After FitzRoy's death in 1865 the Royal Society advised the Board of Trade to discontinue the publication of forecasts, but that "an endeavour should be made to improve the storm warnings, to define the principles on which they are issued and to test these principles by accurate observations". In other words, the investigation was to continue, but in private. This happy state of affairs (happy, that is, for the meteorologist) did not go on for very long. The public demand for forecasts, supported by the British Association, became so strong that the next ten years saw the re-introduction of the public statements of impending weather. Such forecasts have continued until the present day.

Early in the latter half of the nineteenth century (it is difficult to fix the date with greater precision), the Dutch meteorologist, Buys Ballot, recognized the relation between wind and the horizontal distribution of pressure. Buys Ballot's Law, as it is now called, states that in the northern hemisphere an observer with his back to the wind has low pressure on his left hand. (The rule is reversed in the southern hemisphere.) This directed attention to the use of isobaric charts, and it soon became evident that such charts, drawn for pressures reduced to mean sea-level, exhibited certain well-defined patterns that we now call depressions, anticyclones, troughs and ridges.

From the latter half of the nineteenth century until to-day, professional meteorology has been largely preoccupied with the study of the anatomy, life-history and movements of these patterns in the pressure field. The weather forecast is largely based upon the observed behaviour of the atmosphere in the vicinity of such disturbances, but this, of course, is not the whole story. Following Dr. R. C. Sutcliffe, we may consider that the pressure field as a whole comprises the following systems:

Scale	Example
(*a*) Micrometeorological	Cloud elements; turbulence near a boundary.
(*b*) Sub-synoptic	Local showers, thunderstorms, local winds.
(*c*) Small synoptic	Small depressions and anticyclones, tropical tornadoes.
(*d*) Large synoptic	Semi-permanent continental anticyclones; long waves.
(*e*) General circulation of the atmosphere	

The practice of operational forecasting involves only those features of the synoptic chart that are included in (*c*) and (*d*). In general, disturbances of the pressure field of scales (*a*) and (*b*) cannot be 'seen' on the chart; the resolving power of the meteorological network, even in a highly developed country like Britain, with many airfields, is far too low to allow more than a small fraction of all the showers and minor storms to be recorded. The disturbances that are indicated on the forecaster's chart have something of the character of external waves in that the shape of the stream-lines of the motion is not very different at different levels and the change of wind with height is approximately the same along

* Substance of a Friday Evening Discourse given at the Royal Institution, London, on November 4.

all the verticals within a restricted region. It is thus possible to approximate to a typical atmospheric disturbance of the synoptic scale by a two-dimensional model, and much of the early work on dynamical meteorology was concerned with such models. The outstanding feature of such disturbances, however, is their slow translational motion. The typical depression of these latitudes moves across the country at a speed between 20 and 30 m.p.h., and it is important to recognize that other disturbances, such as sound waves and gravity waves, move far too rapidly and are of too small an amplitude to have any appreciable effect on weather.

We can get an idea of how the meteorologist of to-day works by considering two of the daily publications of the Meteorological Office. The first is the *Daily Weather Report* containing, on its inner pages, the familiar isobaric charts for the northern hemisphere and, on a larger scale, for the north-western corner of Europe. The pressure field depicted is that for a hypothetical mean sea-level surface—which may or may not coincide with the real surface of the globe. All observations, whether on high or low land, have been reduced by a mathematical formula to 'zero height'. This type of chart is too well known to need further description. The second publication, the *Daily Aerological Record*, is not so familiar. The inner pages of this publication contain two sets of maps, namely, contour charts of the 700-, 500- and 300-millibar pressure-levels and thickness charts for the strata between the 1,000-, 700-, 500- and 300-millibar pressure-levels. These terms need some explanation. A contour chart shows the height, in feet, of a surface of constant pressure above mean sea-level. This type of chart has largely replaced the constant-height chart for upper-air work for a variety of technical reasons that need not concern us here. The thickness chart shows the relative topography of the constant-pressure surfaces, and, by inverting the familiar barometric-height formula for an isothermal atmosphere, it is easily seen that the difference in height between two isobaric surfaces (that is, thickness) is proportional to the mean temperature of the stratum of air contained between them. In other words, thickness lines are isotherms of mean temperature, and instead of the customary 'lows' and 'highs' of pressure on a constant-height surface we now have 'cold' and 'warm' centres.

These considerations have important repercussions on the forecasting of winds at great heights, that is, for modern aviation forecasts. It was early realized in meteorology that the simplest possible relation between the pressure distribution and the wind is that given by the so-called geostrophic balance. Left to itself, any fluid tends to move from regions of high to regions of low pressure, but in non-equatorial latitudes the effect of the earth's rotation on the atmosphere is to be reckoned with as well. As a result, winds deviate and blow around centres of low and high pressure in the senses indicated by Buys Ballot's Law. If it be further assumed that the wind strength is automatically adjusted to achieve a balance between the pressure and deviational forces, the resulting motion is along the isobars. This motion, known as the geostrophic wind, is a good approximation to the actual wind at about 2,000 ft. above a level surface. The geostrophic wind can be found very easily, by means of a transparent scale, from the contour lines of any isobaric surface. The vector difference between the geostrophic winds on any two surfaces is called the thermal wind. The name is derived from the fact that this wind can be estimated graphically, like the geostrophic wind, but now from the thickness lines, or isotherms, with the thermal wind blowing cyclonically around a 'cold' centre and anticyclonically around a 'warm' centre. One of the most important facts about such centres is that they play a large part in 'steering' the depressions and anticyclones.

Thus modern forecasting has a pronounced three-dimensional aspect. The information necessary for the construction of the upper-air charts is obtained mainly by the radio sonde or its latest development, the radar sonde. In the radio sonde, pressure, temperature and humidity are transmitted back to earth as musical notes. Measurement of the pitch of these notes gives the value in its proper units of the entity being considered.

What is the future of forecasting? Has there been any marked improvement in the accuracy of the published forecast in, say, the past twenty or thirty years? Neither of these questions is easily answered. The phrase 'accuracy of forecasts' conceals one of the outstanding difficulties of meteorology, namely, that of evaluating the degree of success attained in an objective fashion. The present situation is perhaps best summed up by saying that the basic question for the ordinary person, "Will it rain to-morrow?", cannot be answered with markedly greater precision to-day than it could twenty years ago. On the other hand, the meteorologist now can answer many questions, especially those relating to high-altitude flights, which he could scarcely have contemplated in the early 'thirties. There are three great problems confronting the forecaster: how to improve the forecast of the general situation, that is, of the movements of disturbances that produce the daily fluctuations of weather over the British Isles; how to improve local forecasting, that is, forecasting for restricted regions for the next six, twelve or twenty-four hours; and how to produce reliable long-range forecasts, that is, forecasts of the general character of the weather in, say, the coming month. There are, of course, many other problems of comparable importance, but I will restrict my attention to these.

The problem of forecasting the broad features of the pressure distribution over the British Isles and the surrounding seas for a period of twenty-four hours amounts to what is called professionally the production of a 'prebaratic', or chart showing the distribution of pressure at the end of the prescribed period. At present this is done by extrapolation. The forecaster deduces the likely movements of the main disturbances by a combination of experience and physical reasoning. The process, naturally, is highly subjective and liable to be badly in error at times. In this sense weather forecasting might be described as more of a craft than a profession, since much of the skill is acquired by experience with older hands who, in the course of years, have developed a 'nose' for coming changes and often include a good deal of intuition in their prognostications. Progress in this craft is now slow, if it exists at all. During recent years, however, the situation has undergone a radical change. It has long been a dream of meteorologists that some day it will be possible for their science to approach the precision and infallibility of spherical astronomy; but the tremendous complexity of the meteorological problem and the relative paucity of data have made a "Nautical Almanac" of the weather seem more improbable than interplanetary travel. A notable attempt to produce a system of mathematical

forecasting was made by the late Dr. L. F. Richardson in his book "Weather Forecasting by Numerical Process", published in 1922. The attempt was abortive in that the one example worked out by Richardson (using inadequate data) was badly in error; but the principles used were novel and largely correct, and thus the seeds were sown. The development of the high-speed electronic computer in the years following the Second World War, together with a better understanding of the difficulties of the problem, have now made it possible to contemplate the introduction of purely mathematical methods into operational forecasting. This has already been done in the United States and in Sweden.

It is impossible, in this article, to go into the highly complicated mathematics in any detail. Briefly, the method is as follows. At any zero of time we may consider that the pressure and motion fields are known, approximately, for a series of levels over a wide area of the northern hemisphere. The subsequent changes in these fields are governed by the known laws of physics; but it is impossible to proceed using the full exact equations, because they are too complicated and also because there are insufficient data and knowledge available to evaluate all the terms. Instead, certain simplified forms of the equations of motion are used to predict the changes in the pressure patterns during the next twenty-four or forty-eight hours. The mathematician, starting from a known distribution of pressure, uses the method of step-by-step integration to produce the final pattern. Even with the very simple models used, the work involves many millions of mathematical operations and could not be contemplated as a realistic exercise without electronic aids. Modern machines, however, can complete the solution in less than one hour, and the total time taken to produce a forecast chart is perhaps three or four hours.

In Great Britain the study is regarded as still in the research stage, and as yet no attempt has been made to bring machines into operational use. The results of trials with past charts are encouraging, and it is remarkable that simple models have done so well. The consensus of opinion, in Britain and elsewhere, seems to be that numerical forecasting offers the brightest hope seen for many years of substantially improving routine weather forecasts. It is possible that in the next decade or two the development of the method may result in the near elimination of 'major errors' in the forecast of the movements of large-scale disturbances. If this optimistic prophecy is realized, scientific weather forecasting will have made its greatest advance since its inception nearly a hundred years ago.

It is important to realize that this approach, at present, is restricted to prognostication of the pressure distribution with an indication of the broad features of the vertical motion. The weather still has to be deduced from the forecast chart by the human being using time-honoured methods, that is, mainly by a study of the geometry of the forecast pressure field. This is no easy task. Further, such studies relate only to the macroscopic features of the pressure and motion fields and therefore concern only the general situation. Forecasts of local weather, where these involve prognosis of the fine structure of the field, are outside the scope of the mathematical study. Yet, clearly, it is very desirable to be able to time fairly accurately the approach of a rain belt or a large thunderstorm for a densely populated area like Greater London.

It seems that the main hope for any improvement here lies, not in increasing the complexity of the synoptic chart, but in quick, accurate and frequent reporting. For this the meteorologist must be able to scan the atmosphere in his vicinity as well as to consult his chart, and here again he can now call on electronic aids. Within the past few months specially designed radar equipment has been installed on the roof of Victory House, Kingsway, London, for this purpose. The equipment works by the reflexion of 3-cm. waves from rain-drops, hailstones, snowflakes and particles of ice—the normal constituents of rain-producing clouds. An approaching storm of sufficient intensity can thus be seen as an echoing area on the cathode-ray tube, sometimes as much as a hundred and fifty miles away. But the radar method is selective in that it cannot 'see', for example, fog and mist. Aids such as this radar equipment, especially if suitably multiplied and coupled with a detailed study of the weather peculiarities of a restricted region, could lead to a much-improved service to the public.

Thus the 'further outlook' for short-range weather forecasting is not unpromising, and a judicious blend of the mathematical approach, with the continuing detailed study of the anatomy of weather systems, can be expected to yield good results in the not too distant future. But it is otherwise with the problem of long-range forecasting. Present methods of forecasting for twenty-four hours ahead have been extended to four-day periods, mainly by an intensive study of conditions in the upper layers of the atmosphere; but the degree of reliability decreases rapidly with the length of the period. In general, in temperate latitudes, there is usually no unique relation between the synoptic situation at any given time and that five days or more later. This illustrates what is perhaps the major difficulty in forecasting weather. Influences that were initially below the threshold of observation can grow and become dominant in a period as short as a few days, so that new initial conditions have to be introduced at frequent intervals. In this sense the problem of weather seems to be indeterminate, and a limit is imposed on the applicability of present methods of numerical forecasting which is unlikely to be removed by refinements in the mathematics. Even the most elaborate model is unlikely to produce trustworthy results from a single situation more than seventy-two hours ahead (except in certain highly stable situations, such as a well-developed summer anticyclone), and on many occasions the maximum period of validity may well be no more than forty-eight hours.

Despite many patient researches, particularly in Germany, there does not seem to be at present any real basis for reliable forecasts for periods of a month or more. Even less reliable are forecasts of the general nature of seasons, for example, whether the coming winter will be mild or severe. There is no well-defined rhythm in atmospheric processes (except for the cycle of the seasons) on which such forecasts can be founded. On the other hand, there are many tantalizing clues that there may be subsidiary rhythms, and this, no doubt, accounts for much of the assiduity with which investigations into long-range forecasting have been pursued. There is, for example, evidence to support a belief in the reality of singularities—periods of characteristic weather (such as dry, rainy or stormy)—that tend to occur about the same date in most years, but these are by no means infallible guides. They indicate, at the most, that not every variety of weather is equally probable

on any given day in the year; but as yet there is no criterion for their appearance or non-appearance in any given year. Research into long-range forecasting has developed chiefly on two lines: the purely statistical approach, and the dynamical method. In the statistical approach, little or no attempt is made to assign physical causes, and the investigator usually confines his attention to a search for significant patterns or repetitions in the weather records. Harmonic analyses of temperature, for example, have been made for very long intervals; but the periods which emerge as 'significant' have not proved sufficiently persistent or of sufficiently large amplitude to form a basis for worth-while prediction. Nor is there any evidence to connect abnormalities in terrestrial weather with astronomical phenomena such as sunspots. The dynamical method has been developed mainly in the United States, where monthly forecasts of departures from climatological means are produced from a study of the larger pressure systems over the northern hemisphere. So far the success obtained is marginal.

Progress in weather forecasting is like climbing a peak in the Himalayas. It is not difficult to obtain a moderate degree of accuracy, but the final stage—that of reaching a high consistent level—is like conquering the last thousand feet on some hitherto unclimbed peak. There is no easy way up, and progress must be, at times, painfully slow. It is not even established beyond doubt that progress is certain; but meteorologists have some reason, at least, to believe that one day the goal will be in sight.

THE LAST VOYAGE OF JOHN CABOT AND THE ROCK AT GRATES COVE*

By Prof. ARTHUR DAVIES
University of Exeter

In 1497 John Cabot sailed from Bristol and discovered about three hundred leagues of the coastal regions and waters of North America. On his return he made a map of his discoveries, and the Spanish Ambassador in London sent a copy to Spain. From this the world map of Juan de la Cosa[1], drawn in 1500, was able to show an east–west coast of sea and land "discovered by the English" with English flags. It can be concluded that Cabot had discovered the Saint Lawrence region and that he had coasted back along south Newfoundland. He was awarded an annual pension of £20 by Henry VII.

In May 1498 John Cabot left Bristol in a fleet of five ships, provisioned for a year, which suggests they did not expect to be back until the spring of 1499. One ship put back to Bristol and reported that Cabot had sailed around the south of Ireland and set course north-west. No English documents record the route or discoveries made in this voyage of Cabot in 1498. His pension, due half-yearly, was paid to his wife on his account at Michaelmas 1498 and on March 25, 1499, but was not paid again. It would seem that he was assumed to be alive until March 25, 1499, but that news of his death was brought back to Bristol soon afterwards. John Cabot never again appeared in English records, and there is no trace of his death or burial in England. In 1939 Denys Hay[2] reported that in a manuscript of Polydore Vergil of about 1512, entitled "Anglica Historia", there is a reference to the death of John Cabot at sea. It reads as follows: "King Henry at the request of one John Cabot, a Venetian by birth and a most skilful mariner, ordered to be prepared one ship, complete with crew and weapons; this he handed over to the same John to go and search for those unknown islands. John set out in this same year and sailed first to Ireland. Then he set sail toward the west. In the end he is believed to have discovered no land [since he did not return, he was not credited with discovery of lands] save in the depth of the ocean, into which he is thought to have gone down together with his ship, being seized by the ocean itself, for after that voyage he was never seen again".

Sebastian Cabot, the second son of John Cabot, transferred to Spanish service in 1512. By 1515 he was describing an important voyage of discovery which he claimed to have made for Henry VII of England. By using the clearest indications from the various versions of Sebastian, his voyage can be described as follows. He set course around the south of Ireland and then north-west and so reached the arctic ice sheet to the east of Greenland. Turning south-west, he rounded the south of Greenland and sailed on westward for about ten degrees of longitude, between 61° and 64° N., in what is now Davis Strait. He met land and kept south and west of it in what is now Hudson Strait. Here the crews threatened mutiny because of the cold and storms, and so on June 11 he turned south and kept along Labrador, east Newfoundland, Nova Scotia and New England. In the latitude of about 38° N. he ended his discoveries and turned back to Europe. Sebastian declared that at his farthest west, in Hudson Strait at 62° N., he was as far west as Cuba and that the sea opened southward (probably Ungava Bay).

The geographical details of this voyage described by Sebastian are so near to truth that they could not possibly have been invented; it is certain that such a voyage of discovery had been made. But it is very unlikely that Sebastian Cabot had led such a voyage. In one account he claimed to have made this voyage in 1494, when he was only twelve years of age, in another 1496, in others 1498 and, by implication, in 1508–9. He was twenty-six years of age in 1508, and this is the only possible acceptable date for him to have been given command of such a voyage. But he took care not to mention his father's voyages at all, and there is no hint in English records of any such voyage with Sebastian aboard, still less that he was in command. In 1521 he was in London, and Cardinal Wolsey urged the London merchants to support a venture under Sebastian Cabot in search of a north-west passage. They replied, without contradiction from the Cardinal: "We think it were too

* Paper read at Bristol before Section E (Geography) of the British Association on September 6.

sore a venture to joperd V shippes with men and goods unto the said Iland upon the singular trust of one man, callyd as we understand, Sebastyan, whiche Sebastyan, as we here say, was never in that land hymself, all if he makes reporte of many things as he has heard his father and other men speke in times past".

The majority of scholars have concluded that Sebastian lied, and that he claimed credit for the discoveries made in the 1498 voyage of John Cabot. In 1929 J. A. Williamson[3], a leading English authority on the Cabots, accepted the claim by Sebastian that he had made such a voyage of discovery, dating it 1508–9. But the evidence of the early Portuguese and Spanish maps of America proves conclusively that such a voyage of discovery had taken place before 1500, when Sebastian was less than eighteen years of age and could not conceivably have been in command.

The Portuguese map of Cantino, drawn in 1502, shows Greenland and the Labrador–Newfoundland region as two utterly distinct and separate lands, which had been discovered for King Manoel of Portugal. In 1500 Gaspar Corte Real discovered Greenland, and in 1501 he coasted Labrador and east Newfoundland as far west as Saint Mary's Bay. This voyage did not pass westward into the Saint Lawrence region, nor did it make any discoveries of land in Nova Scotia and New England. Moreover, it took only a few months, May–October 11, 1501. At some place, probably in east Newfoundland, fifty Indian prisoners were taken[4], one of them being in possession of a broken gilt sword of Italian origin (which points to John Cabot), while an Indian boy was wearing silver earrings of Venetian origin (which points to Sancius, the young son of John Cabot, about fourteen years of age). The only voyage in these waters previous to that of Corte Real was the 1498 voyage of John Cabot. These relics are mute witnesses that John Cabot and Sancius either reached shore alive or that their bodies were washed ashore. Indian custom would ensure that an Indian boy wore the earrings only if they were found on the boy Sancius; otherwise they would have been worn by a man.

All the major Portuguese maps of the period show Greenland and Labrador–Newfoundland as two quite separate land masses, much to the east of their true position to efisure they were within the Portuguese sphere as defined by the Treaty of Tordesillas. This was the official Portuguese concept of the lands of the north-west Atlantic, based on the voyages of Corte Real. They include the Caveri (Canerio) map, the Hamy–King map, the anonymous Portuguese map, all of 1502, the Reinel–Pilestrina map of 1503, the Waldseemuller map of 1507, and others. The name Terra Corte Real is given on most of them to Labrador–Newfoundland, and on some Greenland is named Terra Labrador, after a squire of the Azores who first reported its discovery to Henry VII of England.

The map of the north-west Atlantic by Pedro Reinel is utterly different from these other Portuguese maps. Reinel, the greatest of the Portuguese cartographers, was a free lance and not employed by the Crown. He drew maps from any sources available to him, and this is one which shows virtually continuous continental land from east Greenland to New England. The unusual outlines of Greenland and the region to the west of it are to be explained as the plotting of the ship's track rather than the coasts, an error probably by Reinel. It was originally dated as 1499 by Schmelling; but the map is now assigned to 1502, prior to the other Portuguese maps, by Fontoura da Costa[5] and Armando Cortesao[6], the leading authorities on these maps. It is a Portuguese map with Portuguese names, and its latitudes are nearly correct throughout. It shows nearly continuous continental land from east of Greenland westward by way of Davis Strait, Hudson Strait, Labrador, Newfoundland to New England, ending at about 38° N. The two flags, of Portugal and Spain, indicate the dividing-line of the meridian of Tordesillas passing through west Newfoundland, utterly different from the official Portuguese maps based on the Corte Real voyages. This Reinel map of 1502 corresponds exactly with the discoveries claimed by Sebastian Cabot, thus proving that the voyage which made those discoveries had been completed before 1502. It rules out any possibility that Sebastian could have led it, for he was then less than twenty years of age.

But the map of Juan de la Cosa, drawn in 1500, also shows a continuous continental land mass extending from "the English coasts with flags" northward by way of Labrador and swinging north-east to include Greenland. The coasts are distorted and not comparable in detail with those of the 1502 Reinel map; but the cosmographical concept is identical and the main coastal trends similar. It shows that the voyage which revealed the North American lands from Greenland to New England preceded the Cosa map of 1500, and that it must have been the voyage of John Cabot in 1498. Cosa got the outlines of the 1497 Cabot voyage from the Spanish Ambassador in London. The general outline of the 1498–99 Cabot voyage, brought back by the surviving ship to Henry VII, may well have been copied roughly by the Spanish ambassador and sent to Spain, as had been done in 1497.

The nomenclature of the 1502 Reinel map on the Labrador and Newfoundland coasts is particularly rich, and it reveals numerous associations with the voyage of John Cabot. At 59° N. are the island of fortune and the island of torment. André Thevet[7] stated: "in that place the pilot of King Henry of England thought to have found a strait to pass into the Pacific Ocean. But being in the latitude of 59 degrees north . . . he came to touch at the island of Caravelle where he almost lost his life because of the breakers, rocks and perils that are there. Passing beyond he entered the river of torment." Evidently he escaped disaster by good fortune, and fortune might have come to be the name of the island.

Then come C. domarco, san johan and san pedro, which are the Cape of Saint Mark and the Islands of Saint John and of Saint Peter. In one of the accounts of Ramusio, it was stated that Sebastian Cabot turned back on June 11, owing to threat of mutiny. The name Saint John is an indication that the island was found on, or near, the feast day of Saint John in the Roman Catholic Calendar of Saints. This was June 24, and Saint Peter was June 29, which dates correspond very well with a voyage which turned back at 62° N. in Hudson Strait on June 11. The feast of Saint Mark is April 25; this name occurs twice on this map, which indicates it was not given by reason of its dates but, as was often done, for personal reasons. John Cabot was a citizen of Venice and his patron saint was Saint Mark. When he first discovered land in 1497, he raised the banner of Saint George for England and of Saint Mark for Venice.

Y dos aves is Portuguese for island of birds; C. dos gamas is cape of deer; boaventura means good

luck. Y. do frey luis at 51° N. is the island of brother Lewis or Luis. To-day it is Lewis Island, the English name, not the Portuguese. Most scholars have assumed this indicates the presence of a friar on board, but this is very improbable. Priests never went on dangerous voyages of exploration, only on later voyages of colonization and settlement. Columbus and Vespucci had no priests on their voyages of exploration. The eldest son of John Cabot was called Lewis, and he does not seem to have survived this voyage. The island of brother Lewis may have been named after him.

Baya de Santa Cyria indicates August 8. Y. dos bacalhaos is island of cod fish. Sebastian Cabot told Peter Martyr that he had given this name to east Newfoundland because of the plentiful supply of cod fish found there; but Martyr noted that there were many Spaniards who denied that Sebastian Cabot had sailed so far west and discovered this land. Baya do concepcam indicates the feast of the Conception on December 8, which points to a very long delay in this region. The next name, C. da espera, gives the explanation of this long delay, for it means the cape of waiting. To English ears espera sounds like spear, and Cape Spear occurs on modern maps just south of Saint John. It is possible that John Cabot took only two ships on this westward exploration, the other three ships which sailed out in company from Bristol being bound for Iceland. Thus there would be one consort ship, and it is probable that this ship set up a look-out post at C. da espera and then spent months searching the coasts and rivers to the south and then to the north for signs of survivors. This was the duty of a consort ship, and faithfully they pressed their fruitless search month after month. R. de sam francisco to the south is October 4, while baya do concepcam to the north is December 8. The tragedy would seem to have occurred as follows. After fishing for cod fish near the island of Bacalhaos (the modern Baccalieu island), they turned south to cross Conception Bay. Possibly during hours of darkness the ship of John Cabot "went down in the depth of the ocean being seized by the ocean itself". The description almost implies that it was not wrecked on a coast nor sunk by tempest. "Being seized by the ocean itself" suggests that the consort ship was at a loss to account for the disappearance of the Cabot ship. It is possible that the ship carrying John Cabot struck an iceberg during darkness not far from Baccalieu Island, at the north end of Conception Bay. Near by is Grates Point, and just west of it is Grates Cove. It may be that Cabot, his young son Sancius and some of the crew succeeded in reaching Grates Cove in the ship's boat. Cabot and Sancius certainly got ashore, alive or dead, for the broken Italian gilt sword points to Cabot himself and the Venetian silver earrings to the boy Sancius.

The consort ship must have missed them next day but, assuming they would link up, carried south as far as Cape Spear, when it became apparent something was seriously wrong. Thereafter the crew of the consort ship set up a look-out at this 'cape of waiting' and searched the coasts to the south, and then finally in December, as a last resort, they retraced their course northward and searched Conception Bay, naming it on December 8 after three months of vigil. They may have discovered wreckage of the ship, but most probably gave up the search in December, finding no trace of Cabot. The date, December 8, points clearly to the Cabot voyage of 1498, which did not return to Bristol until after March 25, 1499. The Corte Real voyages were back in Lisbon by early October on each occasion.

Resuming the voyage, the consort ship rounded C. Rase, which means 'flat cape'. English ears noted it as Cape Race, its modern name. The ship crossed the Saint Lawrence to Nova Scotia, and thereafter coasted to New England in mid-winter. The Island of Saint Johan, off Nova Scotia, indicates the feast of Saint John of Ravenna on January 12. After reaching 38° N. the consort ship turned back for England, where its Portuguese pilot, Juan Fernandez, the labrador or squire of Terceira in the Azores, reported the discovery of Greenland, etc., to King Henry of England and the loss of John Cabot with the King's ship. This is noted from the account of Alonso de Santa Cruz, a friend of Sebastian Cabot in Spain, writing in 1541. In his work, "The Voyages of the Cabots" (1929), J. A. Williamson quotes the following passage of Alonso de Santa Cruz: "That region of which we now wish to treat is commonly called the land of the Labrador (Greenland). . . . As for the western side toward the land of the Bacalhaos it is said that two Portuguese brothers, named the Corte Reals, . . . asserted that the mainland, of which they reached the extreme end, was separated from that island of the Labrador by a very large and wide sea channel, of which the pilot Antonio Gaboto also had information. It was called the island of the Labrador because a Labrador of the Azores gave notice and information about it to the King of England, when he sent in search of it Antonio Gaboto, the English pilot and father of Sebastian Gaboto. . . . The land named the Bacalhaos, where the Corte Reals went to colonise, was first discovered by the pilot Antonio Gaboto, the Englishman, by command of the King of England". It may be noted, in passing, that Williamson argues that Santa Cruz was mistaken and knew little about the matter. But Santa Cruz had accompanied Sebastian Cabot on his voyage to the Plate River in 1526 and had close connexions thereafter in Spain with him. It is probable that Sebastian Cabot was the source of this account of Santa Cruz, belatedly giving credit to his father for the discovery of the Bacalhaos before the Corte Reals went there.

These documents and maps show that the 1498 Cabot voyage discovered the continent of North America from Greenland to Delaware Bay in 1498–99. When Cabot went down with his ship, the Portuguese pilot, Juan Fernandez, completed the voyage and reported back to Henry of England. This report found its way through the Spanish Ambassador in London to the 1500 map of Juan de la Cosa in Spain. Fernandez's own chart of the voyage formed the source of the 1502 Reinel map of the north-west Atlantic. It is the only map record and the only surviving document of the last voyage of John Cabot. It serves as a complete and accurate record of that voyage and its proud achievement of discovery in the New World. Since Fernandez held his lands in Terceira under the Corte Reals, captains donatory of the island, it is almost certain that he passed on information of the Cabot discoveries to them. The Corte Real voyages of 1500 and 1501 were, therefore, the outcome of the Cabot voyages.

An important piece of evidence in this reconstruction of Cabot's last days is the large rock at Grates Cove, near Grates Point, north of the headland which terminates Conception Bay and practically opposite Baccalieu Island. This rock, which was

first described in 1822 by William Epps Cormack as "a large block of rock which stands on the shore", bears an inscription, still partly discernible, in which the words Jo Caboto can be plainly traced. Parts of other names are legible, and among these are Sancius and Sainmalia. Leo F. English, curator of the museum at St. Johns, Newfoundland, has recently commented on this rock[8]; he quotes Archbishop Hawley for the statement that Grates Cove comes from the Italian gratia, thanks be to God. No English names can be deciphered.

On the supposition that John Cabot and Sancius with some of the crew got ashore at Grates Cove, it would seem that, knowing the consort ship would search the coasts for them, they inscribed these names on the rock at Grates Cove. No one by the name of Sainmalia is known to be connected with the expedition. It may be that it is the illegible remnant of "Santa Maria save us" or some such expression. It is not credible that such an inscription could be anything but genuine, for no forger before 1822, however learned, knew of the Reinel 1502 map, which was first discovered in 1844, and not until to-day has anyone reconstructed the 1498 voyage of John Cabot and suggested that his ship went down in the vicinity of Grates Cove. One can only assume that Cabot and his party, after inscribing the stone, were overcome and killed by the Beothuk Indians. The searchers from the consort ship never went north of Baccalieu Island and never saw the inscription on the rock. Had they done so, it is possible they might have saved John Cabot and his men, stranded on this wild coast to end their days.

The rock at Grates Cove, the broken gilt sword of Italian origin and the silver earrings of Venetian origin are relics of the disaster which overtook John Cabot. With the aid of Portuguese maps of America they help to reconstruct in detail the fortunes and achievements of the 1498–99 voyage, one of the greatest triumphs over hardship and danger that exists in the annals of American discovery.

[1] Ganong, W. F., "Crucial Maps", *Trans. Roy. Soc. Canada*, Sect. 2, 135 (1929).
[2] Hay, D., *English Historical Rev.*, **54**, 246 (1939); *Camden Series*, **74**, 116 and 117 (1950).
[3] Williamson, J. A., "The Voyages of the Cabots" (London, 1929).
[4] Williamson, J. A., *op. cit.*, 40.
[5] Fontoura da Costa, A., "A Marinharia Dos Descubrimentos" (2nd ed.), 206 (Lisbon, 1939).
[6] Cortesao, Armando, "Cartografia e Cartografos Portugueses", 260 (Lisbon, 1935).
[7] Thevet, André, quoted by J. A. Williamson in "The Voyages of the Cabots", 115.
[8] English, Leo F., "Historic Newfoundland", 14 (St. Johns, Newfoundland, 1955).

LABORATORY DESIGN

SURVEY OF SPACE AND SERVICES REQUIREMENTS IN TWO AGRICULTURAL RESEARCH LABORATORIES

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IN 1954, at the suggestion of the Agricultural Research Council, the Division for Architectural Studies of the Nuffield Foundation began an investigation into the design of laboratories. Work is at present in progress on several aspects of laboratory design, including the arrangement of rooms for convenient circulation, the layout of local and central stores, etc. The problems of laboratory lighting and ventilation, the economics of service installations and the performance of various materials and finishes are the subject of studies being conducted jointly with the Building Research Station. This article describes a pilot survey, made last year, which was designed to throw light on the provision of space and services to meet the needs of scientific workers in the laboratories of the Agricultural Research Service. The survey is being followed by a main one, at present in progress, covering all the laboratories of the Agricultural Research Council and two or three laboratories operated by other authorities. Both surveys are concerned with the design of the common type of laboratory, where work is done at benches; they do not cover rooms designed for special purposes, such as constant-temperature rooms, or the sort of accommodation needed for large-scale work such as engineering research. The results of these surveys and the other studies at present in progress will be placed before a panel of scientists for critical consideration.

When a laboratory is planned, decisions are required as to the provision of space and the supply of gas, hot and cold water, electricity, suction, compressed air, etc., for each worker. Successful design will depend on giving sufficient facilities without extravagance. Some authorities have established standards for space—generally expressed in floor area per worker—but these standards seemed to be arbitrary and to vary without apparent reason. Attempts have been made to throw light on these problems by measuring the floor area allotted in existing laboratories to scientific workers[1]; but this approach takes no account of the fact that the space provided may be too little or too great. Provision of services also varies considerably, and authorities differ widely on what they consider necessary.

It was therefore decided to carry out a survey of the use actually made of space and services by scientists working in reasonably well-provided laboratories; the pilot survey was undertaken to develop practical methods of collecting information and was carried out during April–June 1954 in two establishments—Rothamsted Experimental Station and the National Institute for Research in Dairying at Shinfield, near Reading. These stations were chosen because they cover a wide range of disciplines, and are reasonably well provided with space and services. The results obtained should not be taken as necessarily representative of institutions

of the Agricultural Research Council, or of the needs of scientists throughout the year; but they show the sort of information which can be obtained by the method employed. The main survey, at present in progress, covers a wider range of institutions during a whole year.

The method adopted in the pilot survey was to observe selected individuals at work in the laboratory for a period of one hour each. The individuals, 232 in number, were selected from staff lists supplied by the stations and were grouped together according to grade—scientific officers, experimental officers, or assistants. In the pilot survey the total numbers were too small for significant differences to be distinguished in the needs of the several scientific disciplines. In the main survey the data should be sufficient to bring out these differences, if they occur.

In studies of this sort the presence of an observer may affect the activities of the person observed: to minimize this effect, visits were made in random order, and no individual knew in advance that he was going to be observed. Analysis of the data showed that there was no appreciable change in the pattern of work during the period of the study, and it therefore seems likely that the data collected were not greatly affected by the presence of the observer. Continuous observation for a period of an hour was of value in the pilot survey, as it enabled the observers to see scientific work as a process, and to notice points of general importance in the interpretation of the results. It was found that many of the observations repeated at short intervals during the hour were highly correlated, and accordingly the main survey has been designed to employ the 'snap-round' technique, so that observations on each individual are made at widely separated times.

Bench-Length

The bench-length in use during the period of observation was recorded; where scientists had in use simultaneously two or more lengths of bench in different parts of the laboratory, all such lengths were added together.

Data from the pilot survey were analysed to show the proportion of time that workers in each of the three groups studied used particular lengths of bench. Differences in the lengths used by scientific and experimental officers were small; it was found for these grades that about 12 ft. of benching satisfied one man's requirements for 97 per cent of the time. The data also can be used to show what saving in space arises where a number of men work in the same laboratory; for example, three men working independently in the same laboratory would be satisfied for 97 per cent of the time by 23 ft. run of bench. Assistants were found to need rather more bench-length than scientific and experimental officers; while this result might be expected, it is worth noting that most standard scales of provision allow less space for assistants than for scientists. In practice, small teams often work together. Table 1 shows the bench-length that would be needed to satisfy the needs of a number of teams for varying percentages of time. A finding of some interest was that for 57 per cent of a scientist's time and 33 per cent of an assistant's time, no bench was in use at all.

A somewhat similar analysis can be made for the space occupied by sinks and draining boards, the main difference being that, though these are essential, they are very seldom used—only 1, 2½ and 4 per cent of the time for scientific officers, experimental officers and assistants, respectively. More information is needed; but the indications are that about a 5 ft. length of draining board is sufficient for a scientist, and up to 8 ft. is required for an assistant. These figures would remain about the same for small working-groups, since sinks for washing up are rarely used simultaneously by several people.

Table 1. Bench-Length required for Various Groups of Scientists and Assistants

Number of scientists	Number of assistants	Proportion of time that the bench-length will satisfy the group's requirements 95%	96%	97%	98%	99%
		ft.	ft.	ft.	ft.	ft.
1	0	10·4	11·0	11·6	12·4	13·7
	1	18·0	18·6	19·5	20·6	22·3
	2	25·1	25·9	26·9	28·2	30·3
	3	31·7	32·8	33·9	35·4	37·8
2	0	15·9	16·6	17·5	18·8	20·6
	1	22·9	23·8	25·8	26·2	28·4
	2	29·7	30·7	31·8	33·4	35·8
3	0	20·8	21·7	22·8	24·2	26·4
	1	27·5	28·5	29·7	31·3	33·8
4	0	25·4	26·4	27·6	29·3	31·8

Provision of Services

Another aspect of laboratory design on which the survey material has some bearing is the provision of various services to the bench. For example, data taken from the pilot survey show the average use made of cold-water taps. From this the probability distribution of the number of taps in use at any moment can be found. If a man were provided with four taps, then on certain reasonable assumptions it can be shown that he would use no water for 92·2 per cent of the time, one tap being in use for 7·5 per cent, two taps for 0·2 per cent and three or four taps for a negligible proportion of the time. Service pipes and drains adequate to deal with two taps full on at any moment would in general be entirely satisfactory. The main point to be made here is that this is the kind of information required on which to base standard methods of calculation leading to an efficiently designed service installation. Similar data were obtained for hot water and distilled water. Drainage calculations should take into account all forms of waste water. Data were also obtained for coal gas supplies, and similar calculations show the provision necessary to meet any required proportion of total requirements.

Another service of great importance is electric supply. One way of studying the material is to consider the number of electric points in use at any instant, as with taps for gas or water. It is likely, on general grounds, that such an approach would be very inexact for electricity supplies, as the current used is often very much less than the maximum rating of the socket or fuse. An alternative approach is to consider the variation in the actual amount of current used by an individual. Thus it was found that although scientists used on average 0·60 amp. a.c. at the usual 230-volt level, 4 amp. would be needed to cover the requirements for 98 per cent of the time. The needs of a group of workers could also be calculated as was done for bench-length.

Requirements for Illumination

Information was also collected, using the Illuminating Engineering Society's code values[2], on size of detail and contrast occurring in the work done by the scientists. The results are given in Table 2.

Table 2. Percentage of Time that Various Combinations of Detail and Contrast occurred in the Work of Scientists in Laboratories (excluding Reading and Writing)

Size of detail	Contrast	Scientific officers	Experimental officers	Assistants	Scientific officers and experimental officers together
Microscopy	—	5·0	7·3	2·5	5·6
Minute	Good	3·0	0·0	0·3	2·3
Minute	Average	2·4	0·0	0·2	1·8
Minute	Poor	2·9	4·2	1·1	3·3
Small	Good	3·4	3·4	1·7	3·4
Small	Average	21·8	23·7	22·5	22·3
Small	Poor	11·2	12·1	21·2	11·4
Ordinary	Good	2·2	0·0	0·0	1·6
Ordinary	Average	0·1	1·9	0·2	0·6
Ordinary	Poor	1·2	1·1	2·9	1·2
Dark room		0·1	0·0	0·3	0·1
General activities		46·6	46·3	47·2	46·5
		99·9	100·0	100·1	100·1

Such data will help in specifying the artificial illumination needed, and can also be used to assist design for natural daylight. The daylight anticipated at any point in a proposed laboratory can be calculated from drawings by techniques already established, and compared with the requirements for scientific work. (To assist such comparisons, a study of reflexion factors in typical laboratories is needed, and this is at present in progress at the Building Research Station.)

Time Spent Reading and Writing

Time spent in reading and writing has an influence on laboratory design: it affects decisions as to whether separate office space is necessary for some scientists, and whether laboratories should be designed with space for desks as well as benching. The percentages of the time spent reading and writing while in the laboratory were found in the pilot survey to be 33·8, 30·2 and 7·6 per cent respectively for scientific officers, experimental officers and assistants.

[1] "Report on Space Requirements for Scientific Research Laboratories". By J. Lorne Gray. (Tech. Rep. No. 3. Div. Building Res., Nat. Res. Council Canada, Ottawa; January 1949.)

[2] I.E.S. Code for the Lighting of Building Interiors. (London: Illuminating Engineering Society, 1949.)

THE CHEMISTRY OF INSULIN

IN the *Biochemical Journal* of August 1955 (Volume 60, No. 4) is a communication (pp. 541–556) entitled "The Disulphide Bonds of Insulin", by A. P. Ryle, F. Sanger, L. F. Smith and Ruth Kitai, towards the end of which appears the statement: "the results are summarized in Table 10, which gives the complete structure of insulin". The insulin referred to is from ox pancreas, and in the following paper ("The Structure of Pig and Sheep Insulins", by H. Brown, F. Sanger and Ruth Kitai, pp. 556–565) the small differences in structure between pig, sheep and ox insulins are elucidated.

Dr. Sanger has thus brought to completion the researches which he initiated in 1945 with a paper on "The Free Amino Groups of Insulin"[1]. In this first communication he described the use of dinitrofluorobenzene for the identification and estimation of the free amino-groups of proteins and peptides, a method which depended upon the fact that dinitrofluorobenzene reacts rapidly with the free amino-groups of proteins under very mild conditions. Hydrolysis of the dinitrophenyl derivative of the protein thus formed yielded coloured derivatives, readily separable by chromatography, of those amino-acids which had reacted with the dinitrofluorobenzene. With this new and powerful tool, Sanger was able to show that if the molecular weight of the sub-unit of insulin was assumed to be 12,000, there were six free amino-groups present, two of these on glycine residues, two on phenylalanine residues and two on the epsilon amino-groups of lysine.

At the time that Sanger began this work, the amino-acid composition of insulin was known with a reasonable degree of certainty, largely as the result of the careful analyses of Chibnall and his colleagues; and, on the basis of crystallographic measurements and of findings with the ultracentrifuge, the molecular weight of insulin was believed to be either 36,000 or 48,000, with perhaps a sub-unit of 12,000. Later, measurements of osmotic pressure suggested a figure of 48,000[2]. The task that faced one who wished to determine the complete structure of a protein of this molecular weight would have caused many a lesser man to quail; but fortunately Sanger was not deterred by the immensity of the task. The next important step was the demonstration that oxidation of insulin with performic acid, to break disulphide bonds, led to two separable fractions, the *A* or glycyl chain, and the *B* or phenylalanyl chain[3]. By partial hydrolysis of the two fractions with acid or enzymes[4], and the application of the dinitrofluorobenzene method to the separated peptides which had thus been formed, Sanger and his colleagues were able to elucidate the sequence of the amino-acids in the *A* and *B* chains. Ultimately they demonstrated that their results were compatible with the view that the insulin molecule is built up of two chains, joined by two disulphide linkages, and that the sequence of amino-acids in these chains was, for ox insulin, unique and completely determined. The position of a third disulphide linkage was, at that stage, still obscure. In the meantime the results of others[5] had shown that the molecular weight of insulin was in fact about 6,000, although aggregates could easily be formed. Thus the structure which Sanger had studied was indeed that of the molecule.

The identification of those dicarboxylic amino-acids which possessed an amide grouping[6] involved hydrolysis under very carefully controlled conditions. Finally, the publication to which we have already referred, in the August issue of the *Biochemical Journal*, described the determination of the position of the disulphide bonds by the subjection of insulin to partial hydrolysis, by chymotrypsin and under other conditions in which the disulphide bonds were stable. The cystine-containing peptides in the hydrolysate were separated and their structures determined by the methods previously developed. The structures of the cystine peptides which thus emerged permitted only one solution to the problem of the distribution of the disulphide bonds in insulin, and the conclusion was drawn that in one chain a disulphide linkage spanned six amino-acid residues

in a manner similar to that deduced by du Vigneaud and his colleagues for oxytocin and vasopressin[7].

As *The Times* said on September 5 of Dr. Sanger's work, "It has not only involved an immense amount of painstaking manipulative operations at the laboratory bench, but, what tends to be over-looked, it rests just as essentially on hard logical thinking, in planning the attack and interpreting its results". Nobody who has read Dr. Sanger's papers will dissociate himself from this view. At each step in the development of the work the methods necessary for the solution of the particular problem have been invented, critically surveyed and effectively applied to the problem in hand. The elucidation of the manner in which the multitude of the smaller peptides which were obtained as the result of partial hydrolysis could be fitted together to yield unique structures for the *A* and *B* chains was itself a masterly achievement. The fact that at each stage the results could be interpreted in only a unique fashion demonstrated the validity of the methods used in a manner that was completely convincing. No investigator in this field has disagreed with the results of Sanger's investigations, and now that we know the structure of insulin to be what he finds so far as the chemistry of the problem is concerned, it is for the crystallographers to tell us exactly how in space the structure deduced by Dr. Sanger is to be distributed. There is also the question of the forces involved in the aggregation of the unit molecules. These matters are the subjects of active investigation at the present time.

In his now classical elucidation of the structures of the octapeptides, oxytocin and vasopressin, du Vigneaud based much of his method upon that evolved by Sanger. In the development of his studies du Vigneaud was able to go further than is now possible with a structure like insulin, and succeeded in effecting a complete chemical synthesis of oxytocin and vasopressin, an achievement which has earned him this year's Nobel Prize for Chemistry. Sanger's work has indeed opened up the possibility that insulin itself may ultimately be completely synthesized in the laboratory, although this cannot occur for some time yet.

Sanger's methods and example have set in motion a large force of endeavour in the investigation of protein structure, the limits of which have yet to be visualized. What is now happening perhaps well illustrates the old saying "imitation is the sincerest form of flattery".

[1] *Biochem. J.*, **39**, 507 (1945).
[2] Gutfreund, H., *Biochem. J.*, **42**, 156 (1948).
[3] *Biochem. J.*, **44**, 126 (1949).
[4] *Biochem. J.*, **45**, 563 (1949); **49**, 463, 481 (1951); **53**, 353 (1953).
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NEWS and VIEWS

Chemical Microbiology at Oxford: Prof. D. D. Woods, F.R.S.

The promotion of Dr. D. D. Woods to the new Iveagh professorship of chemical microbiology in Oxford will be warmly welcomed by those who are aware of his distinction in his field. Prof. Woods received his early training in Cambridge, where he worked under the inspiring guidance of the late Dr. Marjorie Stephenson. In 1939 he joined the Medical Research Council Unit for Bacterial Chemistry under Dr. (now Sir) Paul Fildes; he went to Oxford in 1945 and was appointed reader in microbiology in 1946. Among his many contributions is the discovery in 1940, while collaborating with Sir Paul Fildes, of the mechanism of action of sulphonamide drugs; he established the competition between sulphonamides and *p*-aminobenzoic acid, a normal cell constituent which had not been recognized before as such. From 1940 until the end of the War his academic research was interrupted by service with a Ministry of Supply research team (led by Sir Paul Fildes) to study defence against biological warfare. At Oxford he has built up a flourishing school of chemical microbiology. He is at present interested mainly in the synthesis of vitamins and amino-acids by micro-organisms.

The institution of the new professorship has been made possible by a generous endowment from Arthur Guinness, Son and Co., Ltd. This firm has already provided three Guinness research fellowships at Oxford which enable senior research workers to carry out full-time research on the biochemistry of micro-organisms. The many benefactions to scientific research made by Lord Iveagh (who is head of the house of Guinness) were referred to in *Nature* of June 4, p. 975, on the occasion of his appointment to the Order of the Garter.

Botany at St. Andrews: Dr. J. H. Burnett

Dr. J. H. Burnett, lecturer in the University of Liverpool, has been appointed to the newly created chair of botany at the University of St. Andrews. Dr. Burnett entered the University of Oxford in 1940 as a Postmaster scholar of Merton and, after taking the shortened degree course, was commissioned in the Navy. During his service, which was mainly in the Mediterranean, he commanded a landing-craft and was both wounded and mentioned in dispatches. On returning to Oxford, he took Schools again, obtaining a first class, and was elected to a Christopher Welch scholarship. He became a University demonstrator in botany in 1949 and was for a time acting curator of the Fielding Herbarium. In January 1954 he moved to the University of Liverpool as lecturer in botany. Dr. Burnett's interests lie mainly in the application of the broader genetical principles to biological problems. Since 1953, his work on fungal genetics has been supported by a grant from the Nuffield Foundation. His early studies were on the physiology of the mating process in *Mucor*; but more recently he has been interested in the mating mechanisms of the Basidiomycetes and, in particular, the problem of estimating the population size by using mating alleles as markers. In Liverpool he played an active part in the running of a genetical discussion group among the medical staff of the hospitals.

Nematology at Rothamsted Experimental Station: Mr. F. G. W. Jones

Mr. F. G. W. Jones, lecturer in agricultural zoology in the School of Agriculture, Cambridge, has been appointed head of the Nematology Department of Rothamsted, and will take up his new duties in January. Educated at Queen Mary's Grammar

School, Walsall, and Jesus College, Cambridge, he read botany, zoology and chemistry for Part I of the Natural Sciences Tripos, and zoology (specializing in entomology and experimental zoology) for Part II. He graduated B.A. in 1936 and M.A. in 1941. In 1937 he was attached to the old Agricultural Advisory Service at the School of Agriculture at Cambridge, and on the discontinuation of the Service he was appointed successively University demonstrator (1946) and University lecturer (1947). In these roles and as director of studies in agriculture at Jesus College he has been closely concerned with undergraduate and postgraduate education. His research work has been chiefly on plant nematodes. As adviser to the Committee for Sugar Beet Research and Education since 1946, he has attracted to his side an active research team for working on sugar beet pests, principally the sugar beet eelworm, *Heterodera schachtii*. The use of 'microplots', each a few square feet in area, has facilitated adequate mixing and sampling of field soils and has yielded valuable data on changes in the population of beet eelworm under various agronomic conditions. Other lines of work have dealt with the host ranges of this and other eelworms, and the effects of different levels of soil moisture on the hatching and migration through the soil of *Heterodera* larvæ.

Mycology and Bacteriology at the Weizmann Institute of Science, Rehovoth: Dr. Esther Hellinger

Dr. Esther Hellinger, who is retiring from her post as chief mycologist and bacteriologist at the Daniel Sieff Research Institute, now part of the Weizmann Institute of Science, Rehovoth, is one of the band of enthusiastic scientists who have done so much for plant pathology and industrial mycology in Israel. Her investigations have covered a wide field and have all been concerned with problems of practical importance. Her first task was examining experimental shipments of grapes to Britain, every facility for this work being given in London by the late Sir Edwin Butler at the Imperial Bureau of Mycology (now Commonwealth Mycological Institute). In 1926 she went to Palestine again and worked under Dr. I. Reichert at the Agricultural Experiment Station, Tel Aviv, on a number of local plant diseases. During 1928–31 she undertook the investigation of the wastage of citrus and other fruits then causing so much concern to exporters, a project financed jointly by the Empire Marketing Board and the Palestine Government. Her association with Dr. Reichert continued in 1932, and a number of joint papers were published by them chiefly on citrus and banana storage diseases. Late in 1932 Dr. Weizmann invited her to join his staff at the Daniel Sieff Research Institute as chief mycologist and bacteriologist, and she then turned her attention to studies on fermentation processes and the retting of flax. Dr. Hellinger's contribution to science is considerable both in quantity and quality, and it is to be hoped she will long enjoy her well-earned retirement.

New Polarographic Laboratory of the Cambridge Instrument Co., Ltd.

The Cambridge Instrument Co., Ltd., has recently built a small extension to its research department, which is to be used exclusively for work in polarographic problems and techniques, and on November 16 Prof. J. Heyrovský, of Prague, formally opened the building. The Cambridge Instrument Co., Ltd., is a pioneer among makers of polarographs in Great Britain, the earliest instruments being sent out just before the Second World War, and Dr. G. Jessop, of the Company's research department, has done a large amount of work on the development of polarographic instruments and techniques. During recent years the volume of original and outside consultant work has so increased that the new polarographic research laboratory has become necessary. The laboratory will be in the charge of Mr. W. J. Parker, and its specialized services will be available for advice and help to firms and to research workers interested in this subject.

Institution of British Agricultural Engineers

The Institution of British Agricultural Engineers has moved into new premises at 6 Buckingham Gate, London, S.W.1, and all future sessions of the London open meetings of the Institution will be held there.

A new local centre of the Institution has been inaugurated, covering the counties of Monmouthshire, Gloucestershire, Herefordshire, Wiltshire, Somersetshire and Dorsetshire (east of Bridgwater to Dorchester). It will be known as the Western Centre, and its meeting places will be in Bristol and Chippenham.

Unclassified Reports on Atomic Energy

Unclassified reports on atomic energy have hitherto been made available to the public by the United Kingdom Atomic Energy Authority at the Science Museum Library in London and the Sheffield Central Library. To provide for the increasing demand for such documents, particularly from industry, they will now also be sent to the following libraries: Central Library, Birmingham; Mitchell Library, Glasgow; Central Library, Liverpool; Central Library, Manchester; Central Library, Newcastle. Documents deposited in these libraries are freely available to the public, and the libraries have agreed to supply photostat copies at their usual rates on request. The documents are also sent to the copyright libraries and to the Patent Office Library, and some are on sale through H.M. Stationery Office. A monthly list of Authority documents available to the public in depository libraries (including those on sale through H.M.S.O.) is to be issued from the Atomic Energy Research Establishment at Harwell on behalf of all Authority establishments. This list will also include papers published in the scientific and technical press, and an indication of whether reprints of these papers are available. Requests to be put on the mailing list should be sent to the Librarian, Atomic Energy Research Establishment.

Digital Computers of the United States National Bureau of Standards

Since 1946, the United States National Bureau of Standards has been actively engaged in the general field of electronic digital computers, largely for other agencies of the United States Government. The computer programme has been conducted jointly by the Electronics and the Applied Mathematics Divisions of the Bureau: the Electronics Division in Washington, D.C., has been concerned with the development and construction of the two computers (SEAC and DYSEAC), components research and development, and various technical and advisory services; and the Applied Mathematics Division has conducted research on numerical analysis of import-

ance in the solution of problems by computers and the design and construction of the computer (SWAC) at the Bureau's Institute of Numerical Analysis at Los Angeles. Circular No. 551 of the National Bureau of Standards (pp. 146. Washington, D.C. : Government Printing Office, 1955 ; 2 dollars) is a bound book in which the more important engineering aspects of the Bureau's electronic computer programme are presented. It is based largely on the experience gained in relation to SEAC (National Bureau of Standards eastern automatic computer) and DYSEAC (second SEAC). The contents of the circular consist of eight articles, in addition to an introduction by S. N. Alexander, who gives a brief résumé of the historical development of the programme. The topics discussed in the articles include dynamic circuitry techniques, design of systems, high-speed memory development, input-output devices, construction and maintenance, in addition to a review of three years of operational experience on SEAC.

Both SEAC and DYSEAC are high-speed, automatically sequenced, electronic digital computers, in which extensive use is made of germanium diodes for switching and gating. They have mercury delay-line internal memories, and SEAC has an additional electrostatic memory. Since September 1950, SEAC has been in almost continuous daily use, but interspersed with its productive computational operation there have been periods during which research and development have been conducted on it. The new constructional techniques that have resulted from the experience with this computer have been incorporated into DYSEAC, and this latter represents a considerable advance in the computer art, though it was designed to serve as an experimental nucleus for more complex data-processing networks.

The Shape of the Earth

The different methods for determining the Earth's ellipticity c are discussed by G. Tiercy in No. 50, Series *A*, of "Publications de l'Observatoire de Genève" (Fasc. 1 of Vol. 6). The four main methods are : the geodesic method by measuring the length of 1° of the arc of a meridian ; the determination of gravity at various latitudes ; the precessional method ; and the perturbations observed in the motion of the Moon. While the geodesic value 1/297, adopted in 1911 by the International Conference of Astronomical Ephemerides, is adhered to, nevertheless there exists some uncertainty regarding its accuracy, for the value of 1/294, obtained from the results of the lunar dynamics, still presents a difficulty in accepting a unique and definitive value of c. Reference is made to Bulletin No. 78 of the United States National Research Council, published in 1931, which contains a memoir by W. D. Lambert, who expressed the opinion that the dynamic solution could be made to approximate to the geodesic solution if one or the other of three possibilities was accepted : changes in the values of the secular variations deduced from observations ; changes in the data for the Earth's figure ; and contingent corrections in the very complex mathematical theory of the problem. Tiercy then proceeds to consider another possibility, which may be briefly summarized as follows. In 1932 Wavre dealt with the problem of the oblateness of the Earth, retaining terms of the order of ω^4, ω being the angular velocity, and obtained for the terrestrial meridian a slightly flattened curve with reference to an ellipse with the same poles and the same equatorial radius. The theoretical value of the flattening obtained by Wavre was $c = (a - b)/a \doteqdot 1/295$, and the small portion Δ intercepted by the radius between the two curves is derived from $\Delta = \frac{1}{4} kb\omega^4 \sin^2 \varphi'$, where k is a constant and φ' the geocentric latitude. From this it was found that $\Delta = 310$ metres. With the aid of two diagrams, Tiercy shows that Wavre's investigations practically eliminate the discrepancy which was obtained for c, by the following compromise. Taking the surface of the Earth to conform to the international ellipsoid ($c = 1/297$) but flattened in accordance with the formula given above, the flattened globe would behave very closely, from the point of view of lunar dynamics, as an ellipsoid in which $c = 1/295$. Admitting that it is only a compromise, it is suggested that it can last until a more ingenious interpretation will produce reconciliation of the different results.

Year Book for 1955 of the Library Association

A feature of the Year Book, 1955, of the Library Association (pp. 193 ; from the Association, London ; 21*s.* ; 15*s.* to members) continues to be the usual graded list of text-books and works of reference, which has a value far from confined to those preparing for the examinations of the Association, the regulations and syllabus for which are also given. The entries under science and technology are well chosen and balanced, and the scientific worker himself might well turn to these lists for references to books on general science, including the history of science, natural history and biological sciences. For the science teacher they should be particularly useful.

American Association for the Advancement of Science : Meeting in Atlanta

The 122nd meeting of the American Association for the Advancement of Science will be held in Atlanta, Georgia, during December 26–31. Sixteen sections of the Association and approximately sixty-five affiliated and associated societies will meet concurrently in Atlanta. The programme includes a joint meeting of the Association with the Oak Ridge Institute of Nuclear Studies, at which twenty-two papers on "Atomic Energy and Agriculture" will be given, and three symposia on, respectively, the new psychiatric drugs, the treatment of alcoholism, and recent concepts in clinical chemistry. Dr. James R. Killian, jun., president of the Massachusetts Institute of Technology, will give the Sigma Xi Lecture, and Mr. Newman Bumsted, assistant chief of cartographic staff, the National Geographic Society Lecture, his subject being "Atlantic's Farthest Shores". Further information about the meeting can be obtained from the Director of Public Information of the Association, Dr. Sidney S. Negus, Medical College of Virginia, Richmond, Virginia.

Soviet Science To-day: Symposium in London

A symposium on "Soviet Science To-day", arranged by the Society for Cultural Relations with the U.S.S.R., will be held on November 29 at 7 p.m. in the Caxton Hall, Victoria Street, London, S.W.1. The symposium will take the form of a question-and-answer meeting, and questions should be submitted in advance. Three aspects of current developments in the U.S.S.R. will be considered by the following : Academician N. V. Tsitsin, director of the Permanent Agricultural Exhibition, Moscow (on agriculture) ; Prof. C. F. Powell, professor of physics in the University of Bristol (on atomic energy) ; and Dr. S. Lilley, of the Department of Extra-Mural Studies,

University of Birmingham (on automation). In addition, Mr. J. Allan Cash, a photographic journalist, will show slides of a number of photographs which he took last August in the U.S.S.R. Prof. Powell and Dr. Lilley have also visited the U.S.S.R. during August and September of this year. Admission tickets to the symposium (price 2*s.*) and further information can be obtained from the Society for Cultural Relations with the U.S.S.R., 14 Kensington Square, London, W.8.

Mineralogical Society

THE following have been elected officers for 1955–56 of the Mineralogical Society: *President*, Prof. L. Hawkes; *Vice-Presidents*, Dr. F. A. Bannister and Dr. F. Dixey; *Treasurer*, Prof. J. H. Taylor; *General Secretary*, Dr. G. F. Claringbull; *Foreign Secretary* and also *Editor of the Journal*, Dr. L. J. Spencer.

With the issue of No. 231 (December 1955) of the *Mineralogical Magazine*, Dr. L. J. Spencer will retire from the editorship, having completed fifty-five years in this honorary office, to which he has devoted his whole time since he retired in 1935 from his post as keeper of minerals in the British Museum (Natural History). The work involved is now so onerous that the Council of the Society has decided to appoint two editors, one of the *Magazine* and one of the *Abstracts*; the new editors will be Dr. M. H. Hey and Dr. N. F. M. Henry, respectively. The Society has recently moved its offices from Burlington House, and its new address is now 41 Queen's Gate, South Kensington, London, S.W.7.

The Night Sky in December

NEW moon occurs on Dec. 14d. 07h. 07m., U.T., and full moon on Dec. 29d. 03h. 44m. The following conjunctions with the Moon take place: Dec. 5d. 15h., Jupiter 6° N.; Dec. 10d. 18h., Mars 4° N.; Dec. 12d. 07h., Saturn 4° N.; Dec. 16d. 20h., Venus 5° S. Mercury, in superior conjunction on December 4, is unfavourably placed for observation during the month. Venus sets at 17h. 10m., 17h. 35m. and 18h. 25m. on December 1, 15 and 31, respectively, and is visible for some time after sunset; but owing to its large southern declination it does not attain a great altitude. Its stellar magnitude varies from −3·3 to −3·4, the visible portion of its illuminated disk decreasing from 0·923 to 0·870; its enhanced brightness is due to its distance from the Earth decreasing from 142 to 129 million miles. Mars rises about 4h. 15m. during December; it moves from a position near $\varkappa$ Virginis early in the month to about midway between α and γ Librae towards the end of the month, its stellar magnitude varying from 1·9 to 1·8 and its distance from the Earth between 215 and 195 million miles. Jupiter rises at 22h. 35m., 21h. 40m. and 20h. 40m. on December 1, 15 and 31, respectively, and remains fairly close to α Leonis, its motion being westward until December 18, after which it is eastward. Its stellar magnitude varies from −1·8 to −1·9 owing to its distance from the Earth decreasing from 478 to 437 million miles. Saturn rises at 6h. 30m., 5h. 50m. and 4h. 50m. on December 1, 15 and 31, respectively. Its eastward motion from near γ Librae towards Scorpius can be observed, its stellar magnitude varying from 0·7 to 0·8; owing to its southern declination, it will not attain an elevation of 22° during the month in the latitude of Greenwich and is not very well placed for observation. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Dec. 3d. 04h. 02·8m., 5 Cnc. (*R*); Dec. 4d. 02h. 48·7m., α Cnc. (*D*); Dec. 4d. 03h. 49·8m., α Cnc. (*R*); Dec. 7d. 02h. 20·2m., *e* Leo (*R*); Dec. 26d. 02h. 28·3m., δ Ari. (*D*); Dec. 27d. 03h. 56·3m., 51 Tau. (*D*); Dec. 27d. 04h. 18·4m., 56 Tau. (*D*); Dec. 28d. 01h. 58·0m., *n* Tau. (*D*); Dec. 30d. 06h. 40·7m., *f* Gem. (*R*). *R* and *D* refer to reappearance and disappearance, respectively. The Geminid meteors attain a maximum during December 11–13, the radiant being close to α Geminorum. An annular eclipse of the Sun, invisible at Greenwich, takes place on December 14, and will be visible in the Sudan, the Indian Ocean, Thailand and part of China, the partial phase being visible generally over Africa and Asia.

Announcements

DR. OTTO MAASS, principal research officer in the Division of Pure Chemistry of the National Research Council of Canada, and formerly Macdonald professor of physical chemistry and head of the Department of Chemistry of McGill University, has been elected an honorary member of the Chemists' Club of New York. Honorary membership is restricted to about a dozen chemists, and Dr. Maass is the only Canadian so honoured. His scientific work has been mainly concerned with the chemistry and technology of paper.

THE National Science Foundation, Washington 25, D.C., has appointed Dr. James M. Mitchell as associate director of the Foundation and Dr. John T. Wilson as assistant director for biological and medical sciences. Dr. Mitchell, a past president of the American Society for Public Administration, was formerly assistant to the director of the Foundation, and Dr. Wilson was formerly programme director for psychobiology.

PROF. J. R. WHITEHEAD, associate professor of physics in McGill University, has been appointed head of the new research laboratories in Montreal of the RCA Victor Co., Ltd. Associated with him will be Dr. Sydney Wagner, also formerly of McGill University, and a number of other physicists, and their work will be in the field of pure physics and electronics research, not necessarily connected with the Company's projects or developments. Prof. Whitehead is British by birth, being a graduate of the University of Manchester and Cambridge, and during 1939–51 he was on the staff of the Telecommunications Research Establishment, working on radar.

MR. W. F. GRIMES, director of the London Museum, has been appointed director of the Institute of Archæology and professor of archæology in the University of London. Dr. E. O'F. Walsh, senior lecturer in the Department of Physiology, the Royal Free Hospital School of Medicine, London, has been appointed to the University readership in biochemistry tenable at that School.

A SYMPOSIUM on the various chemical, biochemical, physiological and medical aspects of heparin, organized by the Società Lombarda di Scienze Mediche e Biologiche, will be held on December 19 in Milan at the Museo della Scienza e della Tecnica, 17 Via S. Vittore. For non-members of the Società Lombarda a registration fee of 1,000 lire will be charged, which will entitle them to a copy of the proceedings. Further information can be obtained from Prof. Walter Montorsi, Pad. Monteggia, Via F. Sforza 35, Milan.

SOUTH-EAST ESSEX TECHNICAL COLLEGE, DAGENHAM

EXTENSIONS TO THE SCIENCE DEPARTMENTS

IT had been apparent for several years that the accommodation for the Science Departments of the South-East Essex Technical College at Dagenham was inadequate. The College was opened in 1936 and at that time there was one Science Department which operated mainly on the ground floor of the now enlarged Science Block. Since that time, the provision of laboratories for the College has remained practically the same, although the demands on this section have developed considerably. One measure of the growth is reflected in the fact that within the past ten years it has been necessary for purposes of organization to split the original Science Department into a Department of Chemistry and Biology and a Department of Physics and Mathematics, and the number of full-time staff has been more than doubled to meet the increased demands. The total number of students attending the College on a full-time or part-time basis is now approximately 8,500, and of these approximately 900 are enrolled in the Science Departments.

Fig. 2. Advanced Optics Laboratory

The deficiency in accommodation became increasingly noticeable immediately after the Second World War, and early steps were taken to plan extensions to the existing block by which two upper floors would have been added, together with extensions outward to the east and west. This block would have included provision, not only for science and engineering, but also for art, architecture and domestic science. The scheme was approved by the Ministry of Education in 1950, but shortly afterwards, as part of a general policy of national economy, approval was withdrawn; however, the Ministry finally gave approval to the present amended scheme. The effect of this has been to exclude the extensions outwards to the east and west and to limit the extensions to two new floors above the original block. In spite of these reductions, the new extensions have resulted in a substantial addition to the accommodation for the two Science Departments, with some classroom accommodation for the Engineering Department.

In planning the accommodation and equipment, consideration has been given not only to the needs of existing courses, including degree courses, but also with reference to new types of courses in applied science to meet the changing needs of industry. To give only one example, a photographic section has been included, and this will provide courses primarily to meet the requirements of industry, where this technique is of increasing importance. It is vitally necessary that the departments of the College should be abreast of modern developments in all the subjects taught and, indeed, in a position to point the way to new advances in the future. The research laboratories will enable postgraduate students to be trained in the methods of research and to work for higher degrees.

Fig. 1. Science Block extensions; from the west end

The new accommodation includes two chemistry research laboratories, two physics research laboratories, advanced chemistry lecture room, large lecture theatre and labora-

tories for general chemistry, physical chemistry, radio and television servicing, advanced radio and applied acoustics, X-ray and high-vacuum work, general physics, heat, sound and optics, magnetism and electricity, advanced optics and photography. Provision has also been made for three engineering drawing offices and three engineering classrooms, and a physics workshop.

The new laboratories have been well equipped and it is only possible to mention a few items; for example, a high-frequency motor alternator set, Hilger standard polarimeter, 'Speedivac' high-vacuum pump, vacuum coating unit, X-ray diffraction equipment, measuring microscopes, single-crystal goniometer, Brown electronic potentiometer, Brunsviga calculating machines, various special cameras and photographic equipment, equipment for physics workshop, spectroscopic chemical analysis, radio and television servicing, audio-radio and high-frequency measurements, electronic measurements, etc.

The Science Departments provide both full-time and part-time courses for B.Sc. special chemistry and special physics, and for the general degree of the University of London, associateship of the Royal Institute of Chemistry, and graduateship of the Institute of Physics. Part-time day and evening courses are provided for Ordinary and Higher National Certificates in chemistry, applied physics and engineering, and City and Guilds of London Institute courses in telecommunications, radio engineering, radio and television servicing, photography, chemical plant operation and metallurgy. Courses have been offered at various times in nuclear physics, high-vacuum technique, electronic measurements, valve technology, advanced mathematics for physicists, chemists and engineers, statistics, theory and practice of X-ray diffraction, theory and practice of spectroscopic analysis, servo-mechanisms, glass-blowing and plant technology.

It is proposed to offer a number of 'sandwich' courses suitable to the area served by the College, and these include applied physics, chemistry, radio and electronics, mechanical and production engineering, and electrical engineering.

The new extensions were opened on November 19 by Mr. Geoffrey Marchand, who was until recently chairman of the London Regional Advisory Council for Higher Technological Education, in the presence of a representative gathering of the County of Essex and other professional and academic bodies interested in the work of the College.

ASSOCIATION OF SCHOOL NATURAL HISTORY SOCIETIES

ANNUAL EXHIBITION, 1955

THE seventh annual exhibition of the Association of School Natural History Societies was held in the British Museum (Natural History), London, on October 15. Once more, the main contribution was from member schools, which sent exhibits from widely separated areas. For example, Ackworth School sent a display illustrating work done in Alderney, Channel Islands, and in Ackworth, Yorks. From farther afield came the log-book of the Natural History Society of Brooks Memorial School, Ootacamund, India; this included some beautifully executed water-colour paintings of local avifauna. Living midwife toads and tadpoles (from Provence in France) were exhibited by Glyn Grammar School, Ewell, Surrey.

There were many collections on show, including an extensive comparative display by Bishop's Stortford College of aquatic larvæ from Bishop's Stortford and Flatford Mill, and an equally extensive collection of twenty-seven species of moss from the Lake District shown by University College School, Hampstead. Cranbrook School, the interests of which lay in the lower vascular plants, showed herbarium sheets of local ferns. A collection of dragonflies preserved by vacuum-desiccation to retain the natural colours was exhibited by Lord Wandsworth College, Long Sutton. This and several other entomological exhibits, such as those of Felsted School, Herts and Essex High School for Girls, Bishop's Stortford College and King's School, Canterbury, showed the painstaking care that is taken by these young naturalists to ensure that their specimens are preserved in optimum condition. The wild tropical silk moths exhibited by Tonbridge School were some of the most beautiful creatures on display that day. On the whole, there were more entomological exhibits this year—a fact noted with approval by several visitors.

It is a frequent criticism of the exhibitions that there are "too many graphs"; but nevertheless the compiling of detailed observations and the plotting of transects and quadrats are essential to serious ecological studies. Detailed charts showing the vegetation of East Coast localities were shown by Felsted School. In connexion with local angling interests, Oundle School had made a complete ecological survey of the Willow Brook, a tributary of the River Nene, which is to be stocked with trout. In another exhibit they traced the colonization of spoil heaps, from open-cast mining, from bare earth to complete cover, over a period of thirty years. Dauntsey's School showed results obtained in studying the relative frequency of orchids on a Downland site, together with preliminary investigations to account for the observed frequencies. Less detailed, yet also worth while, were the line transects made by Brighton and Hove High School for Girls, which also exhibited a fine collection of local Basidiomycetes. Kimbolton School showed the results of botanical surveys made in the grounds of Kimbolton Castle and at a site on the River Kym. A hundred-yard transect clearly demonstrated the effect of shade upon the composition of the field layer vegetation.

To many people, graphs and charts are dull, but in fairness it must be said that this year there was a noticeable improvement in the presentation of results: charts were clearly drawn and labelled; captions were short and to the point; and neatness abounded. Those who, in previous years, had produced results which were undoubtedly valuable but were tediously presented now attempted to enliven their charts with colour, bold lettering and other devices. Thus it has been demonstrated this year that members can not merely produce results and specimens, but they can also produce an exhibition. This point is well illustrated by the display put on by the William Grimshaw School, London. "Discovering Coldfall Wood" was a record of what had been found by pupils in an area of woodland. Where actual specimens could not be brought, their place was taken by photographs, models or paintings, so that a visual account of the wild-life of the wood was presented. Another project directed towards visual education was the film strip being produced

by Orange Hill Girls' Grammar School, Edgware. This showed stages in the preparation of diagrams for a film strip illustrating the life-history of the honey bee.

The exhibition was supported by three guest exhibitors: the Amateur Entomological Society, the School Nature Study Union and the Universities Federation for Animal Welfare. During the afternoon a colour film, "Coral Wonderland", was shown, describing life in and around the Great Barrier Reef of Australia. A catalogue of exhibits was available, and an enlarged edition of this catalogue, giving an account of the exhibition and a complete list of members, can be obtained from the honorary general secretary of the Association, O. N. Bishop, Kimbolton House, Kimbolton, Huntingdonshire, price 10*d*. post paid.

The general improvement in quality of presentation, together with the maintenance of good scientific standards, are pleasing to note. Many of the exhibits were again on view in the Department of Zoology, University College, Leicester, on November 5, when the Association held its first provincial meeting. It is hoped thereby to encourage more Midland schools to take an active part in the work of the Association.

O. N. Bishop

DISSEMINATION OF SCIENTIFIC INFORMATION

A CONFERENCE on the Dissemination of Science, organized by Unesco, was held in Madrid during October 19–22. Twenty-five delegates, representing national associations for the advancement of science and associations of science writers, took part. The United States and most European countries were represented, including Belgium, France, Denmark, Spain, Italy, Western Germany, Switzerland, Greece, Netherlands, Poland, Sweden, Turkey and Great Britain.

A wide range of problems was discussed on an agenda drawn up by the Unesco Secretariat, which agenda was severely criticized by many of the delegates because it failed to embrace the fundamental difficulties of scientific popularization. Nevertheless, many interesting issues were covered, and the widely different practices of the various countries soon became obvious.

Many of the delegates commented on the inaccuracy of scientific contributions appearing in the lay press and on the prevalent tendency of editorial staffs to make unauthorized changes in scientific articles. This particular problem does not exist to any great extent in Great Britain, where almost all papers of repute have a professional scientific correspondent. The position in France, however, appears to be so unsatisfactory that the French Association of Science Writers has devised a scheme which enables newspaper editors to check information rapidly on the telephone. The Association has prepared a chart giving the name and telephone number of scientists prepared to answer questions on given subjects at short notice. The usefulness of such a service is great; but the Conference was at pains to point out that it should be regarded only as a temporary measure, and that the true solution lies in the recruitment by newspapers of adequately qualified scientific writers.

One of the documents prepared by the Drafting Committee under the chairmanship of Sir Ben Lockspeiser, a British delegate, stressed the importance of popularizing science and improving general scientific knowledge among certain special sections of the community, embracing on one hand children and their parents, and legislators and business men on the other.

The future supply of scientists can undoubtedly be improved by awaking the children's interest in science at an early age. Even those who do not take up science will benefit from wider scientific knowledge than the present generation. It is important to interest parents also, for in many cases they will determine the career on which their children will embark. There was considerable discussion on the ways in which this group could be reached.

Mr. C. A. Reichen, of Lausanne, produced a number of copies of an excellent illustrated children's magazine, in which scientific matters were given considerable prominence. This magazine has the support of a number of industrial firms. It was considered desirable that similar publications should be started elsewhere. The need for more scientific programmes on radio and television for children was also discussed.

Prof. E. B. Schieldrop, of Norway, spoke on the value of laboratory visits, which had proved particularly successful in the University of Oslo. Sir Ben Lockspeiser strongly supported this point of view and said that the most valuable feature of such visits was that children and parents were able to see how scientists worked.

Mr. Watson Davis, director of 'Science Service', an American non-profit-making organization devoted to the popularization of science, told the Conference about the scientific clubs which have become popular among young people in the United States. From time to time these clubs organize science fairs—in effect conversaziones—in which all the exhibits are made and demonstrated by the members. These science fairs are well supported by local people.

It was considered that the best approach to the second group—those who control government or industrial policy—can be made through scientific articles written by scientists and science writers and published in the special journals read by the members of the group. A notable example of this technique is the regular publication of articles, on science and its application in industry, in the *Financial Times*. Such articles could help greatly in educating business executives in the possibilities presented by the application of science.

Considerable interest was also shown in the paper prepared by Mr. M. Philips Price, M.P., on the Parliamentary and Scientific Committee. This informal group, which was started in the 1930's, now has considerable influence both in the House of Commons and House of Lords. It acts as a focal point where legislators may meet and discuss scientific, technical and related economic problems with men interested in research. In this way the influential layman may be kept informed of the part which science can play in public affairs.

The Conference agreed that such bodies play a most important part in furthering knowledge of science and that they should be established in other countries for legislators and possibly business executives also.

A considerable amount of time was spent in somewhat futile discussion of science fiction and "the fight against false sciences". There was also much

argument as to whether some form of international organization for co-ordinating the work of national associations for the advancement of science and the national associations of science writers should be set up. Finally, however, a recommendation was adopted to the effect that it was undesirable at the present moment to establish an international organization for these purposes, but that Unesco should consider the possibility of forming a consultative committee to further co-operation between the various national associations if this should prove necessary.

Although the Conference produced no definite or positive conclusions, it was nevertheless valuable in showing that the problems of popularizing science vary greatly from country to country, and in bringing people together with similar interests from many countries.

T. A. MARGERISON

ROYAL BOTANIC GARDENS, KEW

A REVIEW of all aspects of the work of the Royal Botanic Gardens, Kew, during 1954, is presented in the *Kew Bulletin*, No. 1, 1955. The past year has been one of sustained progress, but various problems of accommodation remain acute—for example, the Palm House, the Herbarium and Library—and are receiving close attention. The main activities of the Gardens, however, are being maintained with unimpaired vigour. It is impossible to touch on more than a few of these in this short article, but some idea of the nature and volume of the problems handled may be indicated by some selected references. Thus, the specimens received for the Herbarium, excluding those prepared at Kew from living material, amounted to 55,994; some 9,166 sheets were received on loan; 5,652 were sent on loan; 16,424 sheets were distributed as duplicates; and, in all, some 47,780 sheets were mounted (excluding algae, lichens, fungi and bryophyta, and specimens received already mounted). No fewer than 4,077 botanists paid visits during 1954, many of these being from overseas, attending the Eighth International Botanical Congress at Paris. Here, too, reference may be made to the fact that 2,635 inquiries and plant consignments were dealt with during the year.

As in previous years, important activities were the identification of economic plant products and the supplying of information on economic plants: for example, cinnamon, groundnuts, sesamum, raffia, balsa, senna, sansevieria, capers, opium poppy, aloes, patchouli, pepper, ginger, vanilla and cardamoms. In relation to the present high prices of tea and coffee, various inquiries as to the possibility of growing these crops in new areas received consideration.

For many years the Gardens have rendered an important service to scientific agriculture by maintaining the Quarantine House, the function of which is to prevent the spread of diseases and pests during the transference of economic plants from one part of the world to another. Thus, at the present time, varieties of cacao from the Imperial College of Tropical Agriculture, Trinidad, have occupied most of the available space during the year, these being the most promising of the Imperial College selections of Trinidad trees and some Amazonian forasteros originally collected on the Upper Amazon. Rooted cuttings from these plants have been suitably packed and sent by air to the West African Cacao Research Institute, Gold Coast, and to the Departments of Agriculture in Malaya, Ceylon and Fiji, and, with the exception of a consignment sent to Malaya, are reported to be growing successfully in their new environments. Material of *Theobroma* and the related genus *Herrania*, collected in Colombia in 1952 and sent to Kew via Trinidad, is now on its way to West Africa for the use of plant-breeders there. Various banana and cotton collections are also under surveillance in the Quarantine House.

A further service to countries of the British Commonwealth consists in obtaining plants of potential value. For example, young plants of ipecacuanha (*Cephaelis ipecacuanha* Rich.) have been sent to the Departments of Agriculture in Nigeria, British Honduras and Malaya for local trials.

Work of a rather different kind consists of research on the systematic anatomy of the Monocotyledons; notes on this important and extensive undertaking have appeared from time to time in these columns. Arrangements for the publication of this work in three volumes, of which the first will deal with the Gramineae, have now been made with the Clarendon Press, Oxford. A large number of routine inquiries, relating to miscellaneous botanical materials, including timbers, archæological specimens, and rubbed and powdered herbs, have been dealt with in the Jodrell Laboratory during the year. Among the more unusual samples were nylon bobbins examined on behalf of the Board of Customs and Excise, twigs of alleged apple trees, most of which proved to be plum suckers, submitted by the laboratory at New Scotland Yard, and unsatisfactory pick handles which were found not to have been made of the timber that had been specified.

The report also deals in some detail with the progress that has been made in the preparation of the several regional floras, and with other taxonomic studies, and the cultural work in the different sections of the Gardens is appropriately reviewed. A comprehensive list of publications and a staff list conclude this interesting and important publication.

OPINIONS AND SOCIAL PRESSURE

WHAT is the effect of the opinions of others on our own? How strong is the urge towards social conformity? An American psychologist, Solomon E. Asch, has approached these questions by means of unusual experiments. These, and his findings, have been described in the November issue of *Scientific American*, which contains a number of other articles of outstanding interest as follows: "Trenches of the Pacific", by R. L. Fisher and R. Revelle; "Synthetic Diamonds", by P. W. Bridgman; "Radiation and Human Mutation", by H. J. Muller; "'Empty' Space", by H. C. van de Hulst; "What makes Leaves Fall?", by W. P. Jacobs; "Etruscan Metallurgy", by A. N. Modora; "Too Many Deer", by A. S. Leopold*.

Dr. Asch's investigations were guided by certain underlying assumptions, which to-day are common currency and account for much that is thought and said about the operations of propaganda and public opinion. The assumptions are that people submit uncritically and painlessly to external manipulations by suggestion or prestige, and that any given idea or

* *Scientific American*, **193** (November 1955), 2 West 45th Street, New York. 50 cents.

value can be 'sold' or 'unsold' without reference to its merits. Asch has described his experiments as follows.

A group of seven to nine young men, all college students, are assembled in a classroom for a "psychological experiment" in visual judgment. The experimenter informs them that they will be comparing the lengths of lines. He shows two large white cards. On one is a single vertical black line—the standard length of which is to be matched. On the other card are three vertical lines of various lengths. The subjects are to choose the one that is of the same length as the line on the other card. One of the three actually is of the same length; the other two are substantially different, the difference ranging from three-quarters of an inch to an inch and three-quarters.

The subjects announce their answers in the order in which they have been seated in the room, and on the first round every person chooses the same matching line. Then a second set of cards is exposed; again the group is unanimous. The members appear ready to endure politely another boring experiment. On the third trial there is an unexpected disturbance. One person near the end of the group disagrees with all the others in his selection of the matching line. He looks surprised, indeed incredulous, about the disagreement. On the following trial he disagrees again, while the others remain unanimous in their choice. The dissenter becomes more and more worried and hesitant as the disagreement continues in succeeding trials; he may pause before announcing his answer and speak in a low voice, or he may smile in an embarrassed way.

What the dissenter does not know is that all the other members of the group were instructed by the experimenter beforehand to give incorrect answers in unanimity at certain points. The single individual who is not a party to this pre-arrangement is the focal subject of the experiment. He is placed in a position in which, while he is actually giving the correct answers, he finds himself unexpectedly in a minority of one, opposed by a unanimous and arbitrary majority with respect to a clear and simple fact. Upon him are brought to bear two opposed forces: the evidence of his senses and the unanimous opinion of a group of his peers. Also, he must declare his judgments in public, before a majority which has also stated its position publicly.

The instructed majority occasionally reports correctly in order to reduce the possibility that the naïve subject will suspect collusion against him. There are eighteen trials in each series, and on twelve of these the majority responds erroneously.

How do people respond to group pressure in this situation? First, there are the statistical results of a series in which a total of 123 subjects from three institutions of higher learning were placed in the minority situation described above.

Of the 123 put to the test, a considerable percentage yielded to the majority. Whereas in ordinary circumstances individuals matching the lines will make mistakes less than 1 per cent of the time, under group pressure the minority subjects swung to acceptance of the misleading majority's wrong judgments in 36·8 per cent of the selections.

Individuals differed in response. At one extreme about one-quarter of the subjects were completely independent and never agreed with the erroneous judgments of the majority. At the other extreme, some individuals went with the majority nearly all the time. The performances of individuals in this experiment tend to be highly consistent. Those who strike out on the path of independence do not, as a rule, succumb to the majority even over an extended series of trials, while those who choose the path of compliance are unable to free themselves as the ordeal is prolonged.

The reasons for the startling individual differences have not yet been investigated in detail. At this point only some tentative generalizations from talks with the subjects, each of whom was interviewed at the end of the experiment, can be reported. Among the independent individuals were many who held fast because of staunch confidence in their own judgment. The most significant fact about them was not absence of responsiveness to the majority but a capacity to recover from doubt and to re-establish their equilibrium.

Many of the individuals suspected that the majority were 'sheep' following the first responder, or that the majority were victims of an optical illusion; nevertheless, these suspicions failed to free them at the moment of decision. More disquieting were the reactions of subjects who construed their difference from the majority as a sign of some general deficiency in themselves, which at all costs they must hide.

Which aspect of the influence of a majority is more important—the size of the majority or its unanimity? The experiment was modified to examine this question. In one series the size of the opposition was varied from one to fifteen persons. The results showed a clear trend. When a subject was confronted with only a single individual who contradicted his answers, he was swayed little: he continued to answer independently and correctly in nearly all trials. When the opposition was increased to two, the pressure became substantial: minority subjects now accepted the wrong answer 13·6 per cent of the time. Under the pressure of a majority of three, the subjects' errors jumped to 31·8 per cent. But further increases in the size of the majority apparently did not increase the weight of the pressure substantially. Clearly the size of the opposition is important only up to a point.

Disturbance of the majority's unanimity had a striking effect. In this experiment the subject was given the support of a truthful partner—either another individual who did not know of the prearranged agreement among the rest of the group, or a person who was instructed to give correct answers throughout.

The presence of a supporting partner depleted the majority of much of its power. Its pressure on the dissenting individual was reduced to one-fourth. Most interesting were the reactions to the partner. Generally the feeling toward him was one of warmth and closeness; he was credited with inspiring confidence.

Was the partner's effect a consequence of his dissent, or was it related to his accuracy? There was now introduced into the experimental group a person who was instructed to dissent from the majority but also to disagree with the subject.

Again the results are clear. When a moderate dissenter is present, the effect of the majority on the subject decreases by approximately one-third, and extremes of yielding disappear. Moreover, most of the errors the subjects make are moderate. To this extent the subjects broke away from the majority even while bending to it.

On the other hand, when the dissenter always chose the line that was more flagrantly different from the standard, the results were of quite a different kind. The extremist dissenter produced a remarkable freeing of the subjects; their errors dropped to only 9 per cent. Furthermore, all the errors were of the moderate variety. It was concluded that dissent *per se* increased independence and moderated the errors that occurred, and that the direction of dissent exerted consistent effects.

SCIENTIFIC EXPLORATION OF THE BELGIAN AFRICAN NATIONAL PARK OF THE GARAMBA

By Dr. TRACY PHILIPPS

TEN years before the Second World War, King Albert of the Belgians founded the Belgian African National Parks and the National Parks Institute in Brussels for their scientific study; his scientific adviser was Dr. Victor van Straelen, who was until 1954 director of the Royal Institute of Natural Sciences. Dr. van Straelen is president of the National Parks Institute, where he carries out with foresight and energy the founder's purpose, and to whom the preliminary report of the Garamba expedition is dedicated by its members. Nominated by the King of the Belgians as British member of the Institute, I have for my five-year term taken part in the scientific administration of the Belgian African National Parks; the continuing British members are the Hon. Sir Evelyn Baring, Lord William Percy and Lord Willingdon.

The conservation of natural resources, including the recording of their inter-relation, is the more static of the Institute's two main objectives. In the realm of the natural sciences, the Institute's more dynamic part is for the improving of natural knowledge of how to reconstitute Nature's ill-used or over-used forces, and how to re-deploy them by new methods towards "delivering mankind from the bondage of ignorance" of himself and his surroundings.

No organization offers better opportunity than the Belgian African National Parks for uninhibited observation of natural surroundings, of what grows there and of what lives there, inter-related and influenced by the total environment. These reserves were most carefully chosen at the conjunction of great zoological and botanical zones, and of the meeting places of three main atmospheric currents. Botanically, the Garamba Reserve lies within Engler's Sudanic province, which extends roughly from the Senegal River to the foot of the Ethiopian plateau. The Institute's programme aims at establishing a scientific inventory of the fauna and flora of the reserves of which the Government has confided to it the administration. Thanks to the work already done on this plan, it can be said that the areas occupied by the Institute's four national parks between the Sudan and Rhodesia have become scientifically the best-known part of the African tropics. Only the most careful and systematic exploration enabled these results to be reached, and elements of remarkable interest to be placed at the disposal of organized science. Among the publications issued by the Brussels Institute during the past eight years there can be counted 1,334 new zoological species. These are headed by 561 Coleoptera. From the material collected by the Institute's scientific missions, sixty new botanical species have also been described.

Recently, an important exploration and inventory have been made in the National Park of the Garamba, which lies along the north-western section of the Congo–Nile Divide bordering the Nilotic Sudan. The Garamba is situated on the confines of two great bio-geographic areas, the Guinean and the Sudanic. This recent exploration has been working on a plan differing from its predecessors in the other park reserves. The latter were virtually confined to the collection of zoological and botanical specimens. The Garamba expedition's programme set out to determine all the characteristics of the biological environment, including climate and soil, and then to study the distribution of animals and plants in relation to these conditions. The insect collection alone of the expedition amounts to some 1,500,000 specimens. The number is considerable in view of the sum of the work entailed in the preparation of this fragile and perishable material, which cannot be ready for study before 1956. It will have cost five years in mounting, in the ecological recording of all the conditions surrounding each specimen, and in labelling.

Competent study of collections of this magnitude, essential for serious knowledge of flora and of fauna, present great difficulties due to lack of specialists in various branches of zoology. Thus, several families of insects collected in the Albert National Park (between the Lakes Kivu and Albert, and including Mount Ruwenzori) during the exploration of 1933–35 have not yet been examined for lack of available specialists. The size of the collections from the Belgian African National Parks often constitutes a big problem for the scientist who has to examine them. Thus, an American specialist has found himself charged with the examination of 170,000 specimens of *Chloropidae*, a little fly of which the larvæ of some species live in grass thatch or as parasites on non-vertebrate animals.

It is difficult as yet to appreciate the full value of the results of the recent exploration of the Garamba Reserve. A complete abstract of the observations and collections will first be essential to allow of any general conclusion. The botanical specimens being studied show very numerous species new to the Congo, and one family new to science. The zoological collections from the Garamba include 46,776 vertebrates, of which 2,914 are mammals, 3,122 birds, 4,641 fish, 34,511 frogs, 1,588 reptiles, and a number of albino bats. One bio-geographical discovery has, however, been made. It has long been observed that there is considerable similarity between the fish in the basins of the Nile and of the Congo, without there being any obvious present physical connexion. The Garamba expedition has now found, on the northern border of the Reserve, a marsh situated in a gap in the north-western section of the Congo–Nile divide; this marsh overflows in the rainy season both southward to the Congo towards the Atlantic and simultaneously northward into the Mediterranean basin through the Nile.

Henri de Saeger, who organized and led the Garamba exploration, feels that there is good reason for believing that the results will be found to have brought to science an exceptionally rich contribution.

ORGANIZATION OF DEFENCE RESEARCH IN THE UNITED STATES

DURING the past three years the expenditure of the United States Department of Defense, the Atomic Energy Commission and the National Advisory Committee for Aeronautics on research and development has been at an annual level of 2,000 million dollars. These activities have recently been reviewed by a Sub-Committee of the Committee on Business Organization of the Department of Defense, and this sub-committee has communicated its findings to the Commission on Organization of the Executive Branch of the Government, by which the report has been approved for publication*. The Sub-Committee was charged with appraising and evaluating such research and development activities and determining the degree of overlapping and the cost of such activities in the Department of Defense and other agencies conducting research related to defence. So far as the Atomic Energy Commission is concerned, the Sub-Committee limited its survey to research and development activities relating to atomic weapons and nuclear power production ; but it included those activities of the National Science Foundation that relate to, and are co-ordinated with, the military research and development programmes.

The Sub-Committee's report gives a clear picture of the organization of defence research and development activities in the United States and of the problems encountered in relation to overlapping and co-ordination, the evaluation of new weapons and the use of personnel. In spite of the wide difference in structural organization between the United States and Great Britain, the Sub-Committee's comments and recommendations should be of considerable interest in Britain, both to those concerned with defence research itself and to those concerned with the effective use of scientific and technical man-power and the balance of the effort in research and development, including that between fundamental research and applied research whether for defence or for civil purposes.

Prior to 1953, the Research and Development Board was the only organization in the United States Department of Defense directly concerned with the research and development programmes. Operating through a large group of committees, panels and sub-panels staffed by part-time civilians and officers from the three Departments, the Board did little effectively to co-ordinate and eliminate duplication in these programmes, and in 1953 the Board was dissolved and its functions transferred to the Secretary of Defense, who was provided with an Assistant Secretary (Research and Development). In consequence, a real improvement in effectiveness and economy appears to be developing ; but the Sub-Committee doubts whether the new pattern of itself will produce the degree of co-ordination and integration that is desirable, although the professional capacity of the personnel concerned has, in general, been increasing and the traditional attitudes of self-sufficiency of each of the three Armed Services is diminishing. The Sub-Committee emphasizes that it is essential that the Assistant Secretary (Research and Development) be trained in science and technology. Besides possessing experience in research and development and their administration, he should be supported by an adequate staff with like experience, and the Sub-Committee also recommends the full development of the Research and Development Policy Council, of which the Assistant Secretary is chairman. It did not consider, however, that the creation of a further Assistant Secretaryship (Applications Engineering) was sound and recommended that, if combined operation of the two posts proved unsatisfactory, as it anticipates, the functions of the two should be integrated into the office of one Assistant Secretary. It also recommended that the Secretary of Defense should wisely and fearlessly use his authority to withhold appropriated funds from any research and development project to promote integration of the programmes of the three Departments, prevent duplication and encourage effectiveness and efficiency in the use of research and development funds.

Substantially all the basic research of the Department of Defense is carried out under contracts placed in the civil economy. This policy is approved by the Sub-Committee, which nevertheless considers the level of 20 million dollars in 1954 too low and recommends that it be significantly increased. Expenditure on basic research in the physical sciences by the Atomic Energy Commission is regarded as more nearly in balance with the scope of its activities and with the size of its development programmes. Arrangements for co-ordinating these basic research programmes with that of the National Science Foundation are regarded as excellent, and the present organization of the Department of Defense is considered as adequate for identifying duplication in research and development of weapons if used with continuing alertness and energy. The organization does not, however, provide adequately for the initiation of radically new approaches to systems of weapons, and the appointment of a standing committee of outstanding scientists and technologists, reporting directly to the Assistant Secretary of Defense (Research and Development), is recommended. This committee could canvass periodically the needs and opportunities for studies leading to radically new systems of weapons. While the Weapons Systems Evaluation Group of the Joint Chiefs of Staff is potentially of great importance and can make contributions of real value, the Sub-Committee recommends that this Group be shifted to contract work with a university or non-profit organization, and that it then be expanded to an adequate size. An administrative review of the operations and contributions of the hundreds of committees and consultants used by the Department of Defense and the military departments is recommended, and those found to be ineffective should be discontinued. Maximum use should be made of the National Research Council in establishing such committees.

Criticism of the civilian administration of the research and development operations of the three military departments is severe, and the Sub-Committee recommends the establishment of an office of Assistant Secretary for Research and Development in each of the three military departments. The Assistant Secretary should be trained in science and technology and experienced in the conduct and administration of research and development and should be assisted by a small staff with similar qualifications.

* Commission on Organization of the Executive Branch of the Government of the United States : Sub-Committee Report on Research Activities in the Department of Defense and Defense Related Agencies. Pp. x+91. (Washington, D.C. : Government Printing Office, 1955.) 30 cents.

Commenting on the research and development operations of the three Armed Services, the Sub-Committee considers that too large a proportion—some 50 per cent in 1954—of the Army's appropriated funds for research and development is expended on activities within the Army's own facilities and that a larger proportion should be shifted to the civil economy. It commends the new organization plan created in December 1954, but emphasizes the need for strong staff control and for staffing the organization with officers and civilians of the highest technical competence. Of the Navy, it emphasizes the importance of strong administrative support for the new functions of the Office of Naval Research in co-ordinating and integrating the research and development programmes of the Navy, and for providing a staff of adequate size and technical competence, though the Navy has gone far to develop such officers. The military organization of the Air Force for research and development appears to be sound, but the Sub-Committee was concerned at the fragmentation of Army and Navy research and development programmes; whereas the Army pattern is potentially adequate to minimize the consequent deficiencies, that of the Navy is not.

Some 39,000 military personnel and 63,000 civilians participated in the 1954 research and development effort of the three military departments; and while all three departments are giving much attention to personnel problems and have excellent training problems, in view of the increasing national shortage of scientists and engineers, the Sub-Committee recommends that each department should make a realistic examination of its growing needs for technical officers and, if necessary, expand its programmes to provide for an increased number of officers trained in research and development. Each should also revise its policies for such officers so as to permit adequate specialization: the average period of two to three years for the technical assignments is too short. Pay scales should be more nearly competitive with industry, and the number of the higher-level posts in the Civil Service should be materially increased. Where a choice is possible, however, research and development should be carried out at that place in the United States where the work can be done most efficiently and effectively, and it is suggested that some 125–150 million dollars of the programme for 1954 should have been done in the civil economy.

Generally, the Sub-Committee commends the organization for, and the operations in, the military applications of atomic energy, and particularly the Atomic Energy Commission's policy of staff control and co-ordination with operation by civilian contractors. It is concerned, however, that the Department of Defense's assignment of "cognizance" to a military department for certain specific weapons may endanger integration of the development programme and the relations with the Atomic Energy Commission. Unqualified approval is given to the work of the National Advisory Committee for Aeronautics; but it is emphasized that the quality of the work in its laboratories may suffer if salary-levels for professional positions there are not made more nearly competitive with industry. The Sub-Committee anticipates that adoption of its recommendations could bring in the next five years a 25 per cent increase in the effectiveness and efficiency of the present effort in research and development; but it also suggests that in the present rapidly developing technical situation serious consideration should be given to the adequacy of the present level of expenditure.

THERMAL REACTION BETWEEN HYDROGEN AND NITROGEN DIOXIDE

By Dr. P. G. ASHMORE and B. P. LEVITT
Department of Physical Chemistry, University of Cambridge

THERE has been little published work on the reaction between hydrogen and nitrogen dioxide, although there have been many studies of the effect of nitrogen dioxide on the reaction between hydrogen and oxygen[1]. Ashmore has reported[2] sensitized ignitions of mixtures of nitrogen dioxide and hydrogen, and Pollard and Holbrook have kindly informed us of work in Bristol which shows that the two gases ignite at temperatures above 500° C., and that the products of ignition and of the slow reaction are nitric oxide and water. The present communication outlines results, to be published fully later, of a photometric study of the reaction at about 400° C.

Parallel light of wave-length 4450–5000 A., which is below the photochemical threshold[3] for nitrogen dioxide, passed through a plane-ended, cylindrical, 'Pyrex' reaction vessel (20 cm. long, 4 cm. diameter) and fell on a 931-*A* photomultiplier tube; the output, when amplified as suggested by Sweet[4], was proportional to the logarithm of the light absorbed and hence to the molecular concentration of nitrogen dioxide. The photometer was calibrated accurately at 102° C. against nitrogen dioxide in the reaction vessel. The linearity and absolute response at 400° C. were shown to be satisfactory by immediate comparison with admitted quantities and also by comparison of kinetic and equilibrium studies for the reaction $2NO_2 = 2NO + O_2$ with published data[5]. The absence of any photochemical effect on the hydrogen – nitrogen dioxide reaction was confirmed by duplicate runs with a neutral density filter (of ¼ per cent transmission) first between the light source and the reaction vessel, and then between the latter and the photomultiplier.

Fig. 1 shows typical plots of the concentration of nitrogen dioxide against time for a wide range of hydrogen pressures, with 10 mm. of nitrogen dioxide present initially, at 411° C. The rate of disappearance of nitrogen dioxide is more rapid the more hydrogen is present. It is also initially more rapid the more nitrogen dioxide is present.

Nitric oxide has a strong inhibiting effect, as shown in Fig. 2; in these experiments, mixtures of nitrogen dioxide and hydrogen were run into nitric oxide already in the reaction vessel. The effect cannot be

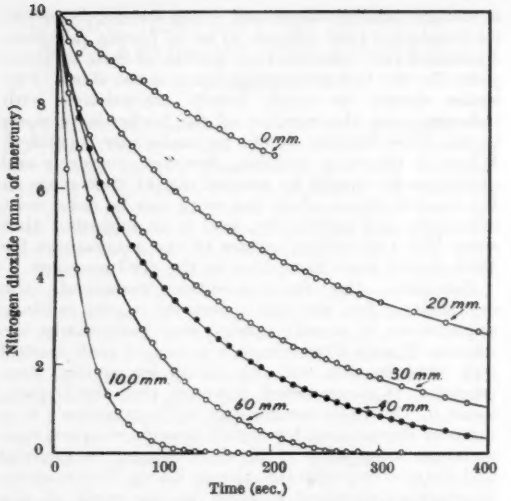

Fig. 1. Decay of concentration of nitrogen dioxide with time. 10 mm. of nitrogen dioxide with indicated pressures of hydrogen, at 411° C.

due to the termolecular reaction between nitric oxide and oxygen, for calculations based on equilibrium data[5] and observed rates for the bimolecular decomposition show that several tens of millimetres of oxygen would have to be present, whereas the amount there is negligible.

The effect of several tens of millimetres of oxygen appears to be negligible initially, but reduces the rate late in the reaction. The effect of water vapour is also slight except near the end of the reaction, when it appears to accelerate the rate of disappearance of the nitrogen dioxide.

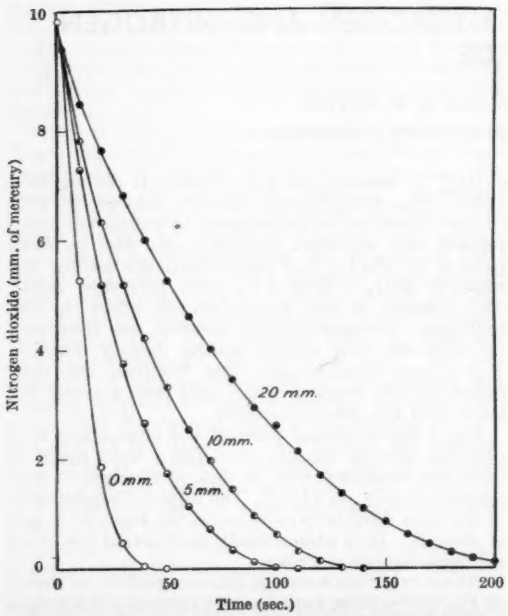

Fig. 2. Inhibiting effect of nitric oxide. 5 mm. of nitrogen dioxide, 100 mm. of hydrogen and the indicated pressure of nitric oxide, at 411° C.

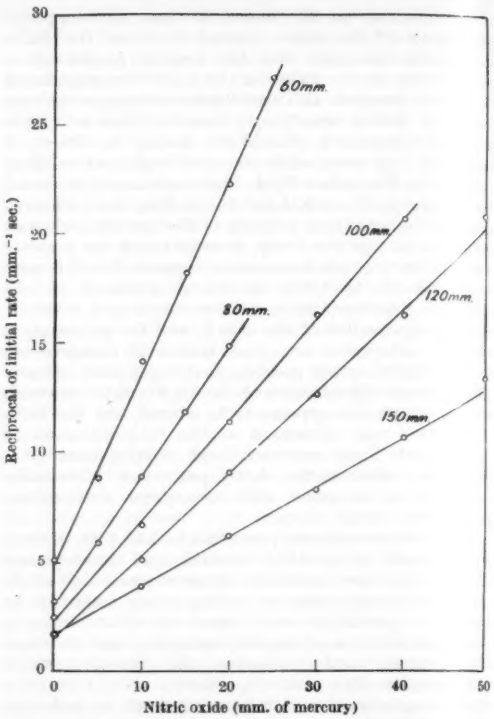

Fig. 3. Plots of the reciprocal initial rate of the inhibited reaction against concentration of nitric oxide added. All runs initially have 10 mm. of nitrogen dioxide and the indicated pressure of hydrogen, at 411° C.

There is no detectable pressure change ($< 0{\cdot}1$ mm.) in the reactions with high ratios of hydrogen to nitrogen dioxide, even when retarded by added nitric oxide. With 10 mm. of nitrogen dioxide and 40 mm. of hydrogen, a pressure increase of 0·2 mm. took place rapidly; this is almost certainly due to the bimolecular decomposition of nitrogen dioxide taking place while its concentration is high. The absence of appreciable pressure change agrees with the stoichiometric equation, $H_2 + NO_2 = H_2O + NO$. An exact analysis of the products has been unsuccessful due to the difficulties of determining accurately small quantities of water vapour; but attempts have shown the bulk, at least, of the products to be nitric oxide and water, as found by Pollard and Holbrook. Calculations for the reaction $3NO_2 + H_2O = 2HNO_3 + NO$ show that the equilibrium concentration of nitric acid is negligible under all reaction conditions[6].

The plots of the logarithm of nitrogen dioxide concentration against time are reasonably linear for the first half-minute with high hydrogen to nitrogen dioxide ratios; the initial rate of disappearance of nitrogen dioxide could thus be determined, and the calculated initial rate of the bimolecular decomposition of nitrogen dioxide subtracted to give the initial rate of the reaction under study.

Fig. 3 shows plots of reciprocal initial rates against nitric oxide added; these are straight lines of reproducible slope, and rather less reproducible intercept, for each ratio of hydrogen to nitrogen dioxide, suggesting the relation:

$$\text{Initial rate} = \frac{A}{[NO] + B}$$

A, the reciprocal slope of the lines in Fig. 3, appears to be first order with respect to nitrogen dioxide. B appears to increase as nitrogen dioxide increases, but to decrease as hydrogen increases. The values of A from the slopes of Fig. 3, and also from plots of initial rates against hydrogen with no nitric oxide added, suggest an order for the initial rate, with respect to hydrogen, between 1 and 1·5. The order for hydrogen in A is at least unity, but it is hard to decide how the remainder is apportioned between A and B. This may be cleared up when the photometer output is amplified and fed to a high-speed recorder instead of the present short-period galvanometer.

Large pressures (about half an atmosphere) of oxygen reduce the initial rate by about 50 per cent, of which calculations show an appreciable part to be due to the reaction $2NO + O_2 = 2NO_2$. However, half an atmosphere of nitrogen also retards the initial rate, although less effectively, so that it is clear that inert gases retard the reaction.

We thank the Royal Society for a grant towards the cost of the photometer, and Dr. B. A. Thrush for his advice on its construction. [July 12

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EFFECTS OF HYPOTHERMIA ON BEHAVIOUR

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UNTIL recently it was generally believed that +15° C. was the lowest level of deep body temperature compatible with the survival of non-hibernating, homoiothermic animals. However, in 1951 Andjus[1] reported the reanimation of adult rats after cooling to much lower body temperatures, during which prolonged respiratory and cardiac arrest had occurred. Since then, improvements in techniques for reanimating rats subjected to extreme hypothermia have been described, and it is now possible to maintain body temperature below +15° C. for as long as 70 min. with an expectancy of complete recovery in a very high per cent of the cases[2-5].

Previous studies have been concerned primarily with the effects of extreme hypothermia on physiological processes; during the course of these studies we became interested in certain general observations regarding the behaviour of the animals. With the exception of a very small number which showed impaired temperature regulation, animals appeared to suffer no noticeable after-effects after successful reanimation from hypothermia at approximately +15° C. or at 0° to +1° C. Animals exposed to the severe treatment recovered reflexes and posture within two hours of re-warming, and afterwards showed apparently normal activity. Although there was some reduction in food- and water-intake during the first 24 hr. after reanimation, there was a return to the normal level or above between the second and fifth days. Within two or three days it was difficult, if not impossible, to distinguish between the behaviour of control and experimental animals living in adjacent cages in the animal colony. Observations of breeding performance gave evidence of a temporary impairment of fertility; but the majority of animals had progeny within three months of exposure to extreme hypothermia. The offspring were healthy and were reared normally by their mothers. In general, it seemed that the very drastic treatment to which the animals had been subjected was not reflected in any serious, permanent impairment of their normal behaviour patterns.

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This is a preliminary report of research designed to study, by means of certain standardized procedures of comparative psychology, the effects on two aspects of behaviour—learning and memory—of reducing the deep body temperature of non-hibernating, homoiothermic animals. Fifty-six hooded rats from the animal colony at the National Institute for Medical Research were used as subjects in two experiments. In the first, two groups of rats were subjected to identical treatments except that the deep body temperature of one group was lowered to between +1° and 0° C. before both groups began learning a serial problem-solving task. The second experiment was designed to include three groups of animals: a control and two experimental groups, the deep body temperature of animals in one of the latter being reduced to between +13·4° and +18·5° C. and that of the other to between +1° and 0° C. Except for the 'hypothermia' phase of the design, all groups in this second experiment received identical treatments in the following order: training on a maze, hypothermia, tests for retention of the maze habit, and training on a serial problem-solving task.

Deep body cooling was done in two stages. The first involved narcotizing the animals by anoxia and hypercapnia as well as deep hypothermia until they became flaccid and lethargic with colonic temperatures at or below +20° C. Animals cooled to temperatures as low as +13·4° C. re-warmed spontaneously when left at ambient temperatures of +20° C. Other animals were subjected to a second stage in the cooling procedure, during which their body temperatures were lowered to between 0° and +1° C. By use of the technique of Andjus and Lovelock[3], these animals were resuscitated completely even after 60–70 min. at body temperatures below +15° C., and after 40–60 min. without detectable heart-beat, circulation or respiration. The results of research by other investigators[6-8] suggests that cerebral electrical activity may have been arrested for as long as 1½–2 hr. Despite this extreme cooling, there is no evidence[5] of the neurological damage to the brain described by other investigators[9].

The results may be summarized as follows. Animals whose body temperature had been lowered to

+ 1°–0° C. showed a significant impairment in problem-solving performance when compared with control animals. On the other hand, no significant differences were found between the performances of control animals and those cooled to +13·4°–+18·5° C. As with such physiological processes as heart-beat and respiration, a body temperature of approximately +15° C. appeared as a 'crucial point' below which performance on later learning tasks was impaired. Our results suggest that this may have been a temporary effect, since the degree of impairment decreased as the interval between body cooling and testing increased.

Although our results show a consistent trend towards poorer retention following hypothermia, the differences among experimental and control groups were very small, and in no instance were they statistically significant. These results support evidence reported by Ransmeier[8] that severe hypothermia, not following immediately after practice of a habit, has little or no effect on measures of memory. This similarity of results is interesting, particularly since Ransmeier's evidence was based upon the behaviour of hibernating mammals following induced hypothermia. Physiological effects of hypothermia at the levels employed are different in such animals from those shown by the rat and other non-hibernating mammals—heart-beat, circulation and respiration being arrested in the latter but not in the former. The fact that suppression of these physiological processes and of electrical signs of brain activity during hypothermia appears to have little or no effect on memory is difficult to explain in terms of a 'dynamic' physiological model[10], in which long-term memory is dependent upon the continuous normal activity of the central nervous system.

Speed of locomotion and amount of food intake were observed in both experiments, and no significant differences were found among the various groups of animals during the periods in which the behaviour measures were being taken. This suggests that the results reported above cannot be accounted for in terms of differences in locomotion or in caloric intake resulting from the different experimental treatments to which the various groups were subjected.

Within the limits of our experimental procedure, we have failed to find evidence that arrest of vital metabolic processes as a result of extreme hypothermia produces any very serious permanent effects on an animal's behaviour once it has been successfully reanimated. This conclusion is, of course, limited to the types of behaviour we have studied, although it conforms with our previous observations made during the course of research on physiological changes accompanying the lowering of deep body temperature. Before final generalizations are made, it would seem desirable to assess the possible effects of hypothermia on other types of behaviour and other species of subjects. [July 22

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CHEMISTRY AND INHERITANCE OF FLOWER COLOUR IN THE DAHLIA

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As a result of the work of Lawrence, Scott-Moncrieff, Price and ourselves[1–6], it is known that the following classes of pigments are concerned in the variations of colour in the garden dahlia (*D. variabilis*):

Magenta, purple, crimson and scarlet shades: anthocyanins.

Yellow shades: chalkones, and aurones[9] (benzylidenecoumaranones).

'Ivory' shades (that is, white petals becoming yellow when fumed with ammonia): flavones and flavanones.

Intermediate shades are produced by combinations of these basic pigments.

Lawrence[1] distinguished the following four basic genes as responsible, singly or in combination, for all the colour variations in the species: *A*, light anthocyanin pigmentation; *B*, heavy anthocyanin pigmentation; *Y*, yellow pigmentation; *I*, ivory pigmentation. He interpreted the bottom recessive condition *a b y i* as that present in 'white' flowers, that is, those not becoming yellow when fumed with ammonia. Lawrence and Scott-Moncrieff[4] mention, however, that the petals of some at least of these white genotypes give a pale straw or maize colour when so treated, the substance responsible giving a green reaction with ferric chloride and being "probably tannin".

It has been of especial interest to us to ascertain the identity of the substances present in the petals of 'white' varieties, since it seemed that this information would be essential to the understanding of the mechanism of variation of flower colour in the species.

D. variabilis is an allo-octoploid species. Each of the genes for flower colour may be present in any number from one in the 'simplex' to four in the 'quadriplex'. The genes *A*, *B* and *Y* are expressed in the simplex and higher condition, but the gene *I* must be at least duplex for it to have an effect. Without deliberate selection, therefore, recessive white genotypes appear exceedingly rarely, but 'whites' can usually be found in a fair-sized planting of mixed coloured seedlings. A chromatogram from one such 'white', *DJ*/18, was illustrated in the first of our publications[6]; but this plant failed to survive and the present work was carried out with a chance seedling of the dwarf Coltness strain, here named

'Clare White'. This plant also failed to survive its second winter, although divided and the portions kept in several different storage places. It seems that these recessive genotypes, as might be expected, are considerably lacking in vigour. However, in its second season, three two-way crosses were made between 'Clare White' and other single-flowered varieties, and altogether 122 seedlings were raised from the six families. Two of the other parents were a bright red and a yellow Coltness variety, and the third a patterned variety, with a purplish eye, shading through red-mauve to blue-mauve at the tip. This 'blend' variety had itself been raised by crossing the commercial varieties 'Chancellor' (crimson-brown with a deep purple-brown eye pattern) and 'Mrs. William Clark' (blend, shading from gold at the base through salmon to red-mauve at the tip). The genetic constitution of these parents was not known, and could only be inferred from the distribution of colour forms in the progeny. The numbers of these were, of course, not sufficient for accurate genetic interpretation of the data.

Of the 122 seedlings, twenty-three were phenotypically white. Fourteen gave an overall yellow colour when fumed with ammonia, two a patterned yellow (shaded from base to tip) and seven no yellow but on longer treatment became maize-coloured and then deep chestnut-brown. Moreover, eight also out of the first fourteen became a deep chestnut-brown when kept for several minutes in ammonia. It was therefore evident that the situation was more complicated than a simple division into 'white' and 'ivory' genotypes; there appeared to be an intermediate group which might be described as 'ivory-white'. The petal pigments of each of the seedlings were therefore studied by paper chromatography.

Identification of the Phenolic Constituents

All the substances with which the present discussion is concerned occur in the tissues of the plant combined as glycosides or (in the case of caffeic and other substituted cinnamic acids) as esters. It is necessary to consider here, however, only the nature of the phenolic residues obtained by hydrolysing the tissue with 2 *N* aqueous hydrochloric acid at 100° and extracting with a small volume of amyl alcohol (cf. Bate-Smith[10]). The petal tube and lower part of the petal were not included in the examination, since in normal flowers these invariably contain yellow pigment. The chromatographic solvent employed was water/glacial acetic acid/concentrated hydrochloric acid in the proportions (vol.) 10 : 30 : 3 (Forestal solvent), in which the anthocyanidins do not fade and the different constituents are well separated; delphinidin and pelargonidin, for example, have R_F values 0·30 and 0·68. With a knowledge of the constituents to be expected, chromatograms can be read by inspection in visible and ultra-violet light, with and without fuming with ammonia. The identity of individual constituents was proved, as occasion required, by *in situ* ultra-violet spectrophotometry on the paper[11] or by elution of strip chromatograms run on Whatman No. 3 paper[8]. Synthetic specimens of all the substances identified have been available for comparison.

Phenolic Constituents of 'White' Genotypes

The main constituent, and that responsible in large degree for the chestnut-brown reaction of the petals when fumed with ammonia, proved to be eriodictyol, in some instances accompanied by naringenin in lesser amounts. The 'ivory-white' genotypes were found to contain, in addition to these flavanones, the flavonols quercetin and (in lesser amount) kæmpferol. It is to these constituents and not to luteolin and apigenin that the 'ivory' reaction in these forms is most often due. Luteolin and apigenin were occasionally present as well as flavonols and flavanones. The presence of quercetin and kæmpferol was, for reasons discussed later, completely unexpected. Once having been detected in the 'ivory-whites', in which they were present in considerable amounts, smaller amounts could be recognized on the chromatograms of 'white' varieties, and it became clear that the 'white' and 'ivory-white' forms differed only in the relative amounts of flavanone and flavonol that they contained. The flavonols also appeared sporadically among the coloured—especially the paler-coloured and the colour-patterned—progeny of these crosses. They were not, however, present in any of a number of larger-flowered, commercial varieties examined.

Influence of Parentage on the Occurrence of Flavonols in the Petals

The common parent, 'Clare White', was a true 'white' genotype in Lawrence's sense and contained only a trace of flavonols. The families from the red and yellow parents, respectively, contained the same relative numbers of 'whites' and 'ivory-whites'. The 'blend' crosses produced only one white phenotype, a 'white', containing a moderate amount of flavonol. The genetic equipment permitting the appearance of flavonols in the offspring resulting from crossing with 'Clare White' would seem, therefore, to be shared by all three of the non-white parents. What all four parents had in common, distinguishing them from the commercial varieties examined, was their derivation from the Coltness strain; but it cannot be deduced from this that it was in itself responsible for the presence of flavonols in the petals. Perhaps because of their rarity (and perhaps also their lack of vigour) no 'whites' or 'ivory-whites' other than *DJ*/18 of non-dwarf habit have so far been encountered.

Significance of the Presence of Flavonols in 'White' Genotypes

There is no reason for disagreeing with Lawrence and Scott-Moncrieff's interpretation of the 'white' condition in flowers of *D. variabilis* as recessive to coloured (including therewith 'ivory'). It is reasonable to suppose (cf. Beale[12]) that, of two allelic genes, that one will be dominant which effects the more elaborate of the two processes expressed, and of all the flavonoid compounds found in *Dahlia*, the flavonols, being the most completely oxidized, should be those requiring the most elaboration in the process of synthesis. Yet it is in a bottom recessive situation that they appear, together with the more expected (because most reduced) flavanones. A certain amount of further information has been obtained by way of a study of the flavonoid compounds in the leaves of a number of genotypes and varieties.

Phenolic Constituents of the Leaves of Dahlia Varieties

Flavonols, leuco-anthocyanins, and complex substances yielding caffeic, *p*-coumaric, ferulic and

sinapic acids[13] are the commonest phenolic constituents of leaves. Of these phenolic constituents, the Compositae do not contain leuco-anthocyanins (*Cosmos bipinnatus* possibly excepted); but the others are commonly present, and *D. variabilis* is not exceptional in this respect. It was found that, irrespective of the colour of the flowers, the leaves of all genotypes contained quercetin, butein, caffeic and ferulic acids, and probably kæmpferol. Of many hundreds of species of plants, including those of a number of closely related Compositae, the leaves of *Dahlia* only have been found to contain butein. Kæmpferol, in Forestal solvent, is overlain by the more highly coloured butein, and when the latter is present cannot be detected by inspection. Its presence in a typical leaf was confirmed, however, as were also the identities of quercetin and butein, by elution from a strip chromatogram as described above.

The situation in the leaf, therefore, as compared with that in the petal, is that the former possesses phenolic constituents—caffeic and ferulic acids—not present (or not conspicuously present) in the latter; it contains quercetin, found in the petals of rare recessive forms only; and it contains a constituent, butein, present in the petal only when a particular gene is present in dominant condition.

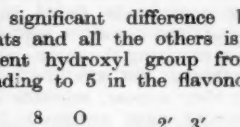
Theory of Factorial Balance in *Dahlia*

Lawrence and Scott-Moncrieff[4] observed the following gene interactions in *D. variabilis*: in presence of *Y*, the action of *I* is suppressed; in presence of *A* or *B* alone, either cyanin or pelargonin is produced; *Y* in presence of *A* or *B* may suppress the formation of cyanin; *I* in presence of *A* or *B* may suppress the formation of pelargonin; a gene *H* is present the inheritance of which, like that of *A*, *B*, *Y* and *I*, is polysomic; *H* cumulatively inhibits the expression of *Y*. There may also be a gene inhibiting the expression of *I*.

As a working hypothesis, it may be assumed that dominant allelic genes acting in the petals modify a situation present generally throughout the soma. If this is so, the action of *Y* should be solely that of suppressing or modifying the action of genes *A*, *B* and *I*, allowing butein then to appear in the *Y* genotype. The actions of *A*, *B*, and *I* in the petal will presumably be mainly exerted upon processes which, in the leaf, lead to the formation of flavonols and chlorogenic acid (the form in which caffeic acid is usually present in the plant tissues).

At this point it is necessary to consider the differences in structure between the various substances produced by the action of the postulated genes.

The most significant difference between the yellow pigments and all the others is the absence of a substituent hydroxyl group from the position corresponding to 5 in the flavonoid skeleton:



Both the aurone, sulphuretin, and the chalkones, butein and 2′,4,4′-trihydroxychalkone, lack this substituent, and it must be through active inhibition of the oxidation of this carbon atom that the epistasy of *Y* is expressed.

The specific actions of *A*, *B* and *I* are concerned only with oxidations at positions **2, 3, 4 and 3′**, since all the substances affected by them are oxidized at positions *5*, *7* and *4′*. The following equivalences should be noted: (1) aurones and anthocyanidins are at the same level of oxidation as the corresponding flavones, the equivalent of one oxygen lower than flavonols; (2) chalkones are at the same level of oxidation as the corresponding flavanones, the equivalent of one oxygen lower than (1).

The action of the individual genes is seldom absolute. We have observed that there is wide variation between apparently identical phenotypes in the relative amounts of their constituent pigments, and while this might be capable of quantitative explanation in terms of the polysomic action of the five postulated genes, *A*, *B*, *Y*, *I* and *H*, it seems more likely that the ultimate result is achieved by competitive action in which physiological (edaphic) factors can play a considerable part (cf. the much lower intensity of anthocyanin pigmentation in late autumn). It seems worth while noting, however, that the balance can be shifted between 4′ and 3′,4′-hydroxy substituted molecules (cyanidin–pelargonidin, eriodictyol–naringenin) and between those more or less oxidized at position 3 (sulphuretin–butein, luteolin–eriodictyol) both dependently and independently. It is worthy of consideration whether these particular oxidations may be carried out by specific enzymes, the ability of which to act is dependent upon a precise pattern of glycosidation of the molecules made available as a result of the presence of particular dominant alleles. A hint of the likelihood of this being the case is provided by the report of the presence in *Cosmos sulphureus* of an enzyme capable of oxidizing chalkone to aurone[14]; by the ability of phenoloxidases to act on phenolic substrates glycosidically substituted in certain positions, but not on the same substrates substituted in other positions[15]; and by the decolorization by normal green beech leaves of anthocyanins present in extracts of leaves of the copper beech[16].

We gratefully acknowledge the assistance given by Sir Ronald Fisher and the staff of the Department of Genetics, University of Cambridge, in raising and growing plants; by Mr. W. J. C. Lawrence and Dr. D. Lewis, of the John Innes Horticultural Institution, for helpful discussion; and by the British Council and the Agricultural Research Council in providing financial support to one of us (C. G. N.). The work described in this paper was carried out as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research. [June 14

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Anode and Cathode Arcs

Arcs which are in general less than one micron in length occur at the opening and closing of low-voltage switches. These arcs are initiated and maintained by field emission currents. They are of two quite distinct kinds which are most readily distinguished by the marks which they leave on polished surfaces.

One type, which we call an anode arc, produces a circular pit on the anode and a general roughening of the opposed cathode. Photomicrographs of single anode-type arcs were published[1] before the second type of arc was discovered. In Fig. 1 is shown the surface of a cathode after the occurrence of a single arc of the second type, which we call a cathode arc. The corresponding anode often shows no mark whatsoever.

A feature of the cathode arc is the way in which it accentuates scratch lines on an imperfectly polished surface. At high magnification in an electron microscope (Fig. 2), each line on the cathode is found to be made up of a large number of single pits, each the result of the explosion of an original roughness by field emission current of very high density flowing through it. Each pit overlaps one of its neighbours,

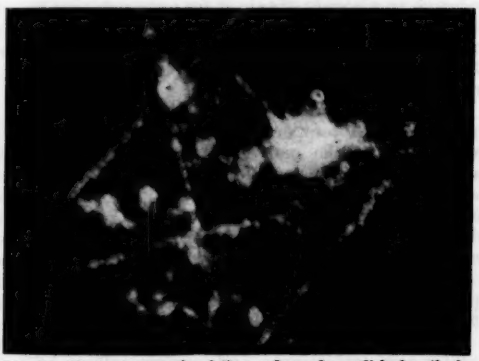

Fig. 1. Photomicrograph of the surface of a polished cathode after a single cathode arc. × 1,200

Fig. 2. Electronmicrograph of part of the mark made on a polished cathode by a single cathode arc. × 19,800. Constant current of 4 amp. for 0·45 μsec.

Table 1. Characteristics of Anode and Cathode Arcs (polished palladium electrodes)

	Anode arcs	Cathode arcs
1. Anode appearance	Hole	Nothing or shallow hole
2. Cathode appearance	Roughened	Along scratches
3. Occurrence Striking potential ⩾ 400 V. Striking potential ⩽ 300 V.	 Never Sometimes	 Always Sometimes
4. Arc voltage	9–12	13–18
5. Striking field	High, 9×10^6 V./cm.	Low, 4×10^6 V./cm.
6. Metal transfer by radioactive tracers	Both directions, net from anode to cathode	Cathode to anode

indicating that an arc was moving intermittently along the original scratch.

Some of the characteristics of the two types of arcs are summarized in Table 1. For palladium electrodes, both cathode and anode arcs occur at striking potentials of 300 V. and lower, with anode arcs favoured by clean surfaces and cathode arcs favoured by dirty surfaces. At 400 V. and higher, only cathode arcs occur. The difference in metal transfer given on line 6 of Table 1 is of importance in understanding the direction and size of the erosion of electrical contacts. It would appear that the confusion associated with erosion measurements in the past is resolved when we identify the type of arc responsible for the erosion.

Experimental details, together with a theory of the mechanisms of the two types of arcs, will appear in a forthcoming paper.

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Neutron Yields from Americium–Beryllium Alloys

The neutron yields from two americium – beryllium alloys have been measured. The alloys were prepared by the reduction of americium trifluoride with powdered beryllium metal in vacuum, according to the reaction :

$$2^{241}AmF_3 + x\,Be \rightarrow 2Am.(x-3)Be + 3BeF_2$$

The beryllium fluoride readily distilled, leaving a fluoride-free alloy.

The α-radioactive purity of the americium was > 99·99 per cent. The total inactive impurities were < 0·5 per cent. Americium trifluoride was prepared by fluorinating americium dioxide with a mixture of dry hydrogen fluoride and hydrogen at 650° C. in platinum. The americium trifluoride was mixed with powdered beryllium, 99·8 per cent pure, and heated in a beryllium oxide crucible at a pressure of 5×10^{-5} mm. mercury. The chemical reaction was followed by observing neutrons from the nuclear reaction $^9Be(\alpha,n)^{12}C$ using a boron trifluoride counter connected to a Marconi scaler.

The results of one beryllium reduction of americium trifluoride are illustrated in Fig. 1. A mixture of

25·9 mgm. of americium as the trifluoride and 279·8 mgm. of beryllium was weighed into a beryllium oxide crucible. When this loose-packed mixture was in position in the cold furnace, the neutron counting-rate was 3,250 counts/min. The rate of neutron-emission remained unchanged at 675°. When the furnace temperature was raised to 900° the counting-rate increased slowly, indicating that the americium – beryllium alloy was forming. At 1,125° the alloy formation was rapid. After eight minutes a constant counting-rate indicated that the chemical reduction was complete. On raising the furnace temperature to 1,375°, where the alloy was molten, the neutron count increased abruptly to 9,100 counts/min. and remained at this level when the alloy was cooled to room temperature. The resulting shiny ingot weighed 275·0 mgm. A comparison of its γ-activity with that of the reduction apparatus indicated that 5 ± 1 per cent of the initial charge of americium had distilled during the heating period to colder parts of the furnace. The estimated americium content of the ingot from these measurements was $24{\cdot}6 \pm 0{\cdot}5$ mgm. Later, the ingot was dissolved in dilute hydrochloric acid. The total americium α-activity in the solution was $2{\cdot}97 \pm 0{\cdot}05 \times 10^9$ disintegrations/sec., as determined by α-counting aliquots from three independent dilutions. The calculated beryllium – americium atom ratio in the alloy, using Harvey's value[1] of 470 yr. for the half-life of americium-241, was 263 : 1.

A second alloy was prepared at 1,125°, with a beryllium – americium atom ratio of 14 : 1. The product was sintered and crystalline. An X-ray powder diffraction pattern of this alloy served to identify $AmBe_{13}$, an intermetallic compound isostructural with UBe_{13}[2] and $NpBe_{13}$[3]. $AmBe_{13}$, beryllium-rich, is face-centred cubic with $a_0 = 10{\cdot}283 \pm 0{\cdot}002$ A. and space group O_h^5-$Fm3c$. Since the ratio of γ-intensities of source 1 to source 2 was $1{\cdot}09 \pm 0{\cdot}01$, the americium α-activity in source 2 was estimated at $3{\cdot}24 \pm 0{\cdot}07 \times 10^9$ disintegrations/sec.

The neutron yields from the two alloys were determined by direct comparison against standard ^{227}Ac-α-Be and Pu-α-Be sources, using a boron trifluoride counter embedded in paraffin. The actinium and plutonium sources had been calibrated against the Chalk River Ra-α-Be standard and a National Bureau of Standards Ra-γ-Be source by activation of a manganese sulphate solution (Hanna, G. C., and Runnalls, O. J. C., unpublished).

Table 1. Neutron Yields from Two Americium–Beryllium Alloys

Source	Be : Am atom ratio	Am α-activity	Neutron yield	Neutrons/10^6 alpha particles*
1	263 : 1	$2{\cdot}97 \pm 0{\cdot}05 \times 10^9$ d./s.	$2{\cdot}13 \pm 0{\cdot}02 \times 10^6$ n./s.	$71{\cdot}7 \pm 1{\cdot}8$
2	14 : 1	$3{\cdot}24 \pm 0{\cdot}07 \times 10^9$	$1{\cdot}57 \pm 0{\cdot}02 \times 10^6$	$48{\cdot}5 \pm 1{\cdot}4$

* The limits of error quoted are due to uncertainties in the americium α-activity determinations and in the comparative neutron measurements. They are subject to a further deviation of ± 5 per cent because of the uncertainty in the absolute neutron yield of the Chalk River Ra-α-Be standard.

The neutron yields are indicated in Table 1.

An approximate method for calculating the maximum theoretical neutron yield from these data has been suggested by Dr. A. P. Baerg (private communication), as follows:

$$\text{Maximum theoretical neutron yield} = n\,\frac{S_{Am} + N.S_{Be}}{N.S_{Be}}$$

where n is measured neutron yield, N is the ratio of beryllium to americium atoms, S_{Be} is atomic stopping power of beryllium (0·63), and S_{Am} is atomic stopping power of americium (4·6).

The values quoted for the atomic stopping powers relative to air were obtained by extrapolating known data for α-particles of about 6 MeV. energy[4]. The calculated maximum theoretical yields were 73·7 and 74 neutrons/10^6 α-particles for sources 1 and 2 respectively.

The abrupt increase in neutron yield from source 1 on raising the temperature from 1,125° to 1,375° is attributed to the conversion of solid $AmBe_{13}$-rich aggregates in solid beryllium to a homogeneous liquid solution of americium in beryllium. The precipitation of americium-rich aggregates would be expected during the solidification of the molten alloy. Since no measurable decrease in the yield of neutrons was observed, however, when the liquid solidified, the particle size of the aggregates must be small compared to the range of the α-particle.

A detailed report on neutron yields from actinium, plutonium, americium and curium alloys will be published later. It should be noted, however, that the neutron yield for $PuBe_{13}$ measured in the above manner is $38{\cdot}7 \pm 1{\cdot}2$ neutrons/10^6 α-particles. If one assumes that the specific activity of the plutonium used by Stewart[5] was $1{\cdot}4 \times 10^6$ disintegrations/min., the neutron yield from her $PuBe_{13}$ source was ~ 40 neutrons/10^6 α-particles.

We wish to thank Dr. J. P. Butler, who supplied the americium, and Mr. J. Baird, who prepared the americium trifluoride.

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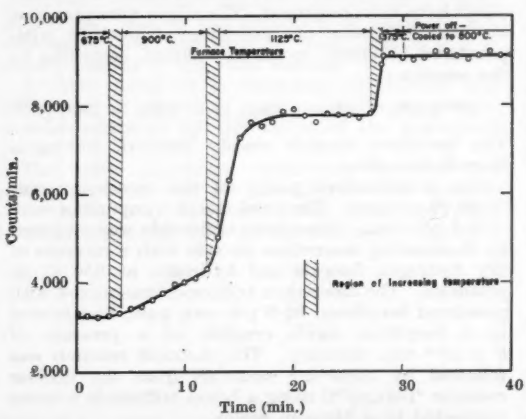

Fig. 1. Measurements of the neutron emission-rate during the conversion of an americium trifluoride – beryllium mixture to a sintered, and eventually molten, americium – beryllium alloy

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Neutrons produced in the Bombardment of Beryllium by Deuterons

THE purpose of the present measurements was to obtain a thin-target yield-function for neutrons[1] for the $^9Be(d,n)^{10}B$ reaction from 0·7 to 1·5 MeV. of deuteron energy.

The neutrons were detected with two Hornyak buttons, 3 cm. in diameter and 1·5 cm. thick (purchased from Isotope Development, Ltd., London), with a magnesium oxide reflector in a thin aluminium box, on 6260 *EMI* photomultiplier tubes. A cathode-follower, a Bell amplifier, an integral discriminator and a scaler were used. The efficiency for fast neutrons, from 0·5 to 5 MeV., is about 1 per cent; for gamma rays it is very low. The geometry used is shown in Fig. 1. The neutron counters were placed as near as possible, so that the angle of detection was $90° \pm 25°$ with respect to the deuteron beam. A Cockcroft–Walton accelerator with a maximum voltage of 1·5 MeV. was used. The beam of deuterons was deflected through 30° by a magnetic analyser. The $^9Be(p,\gamma)$ reaction was used for calibration.

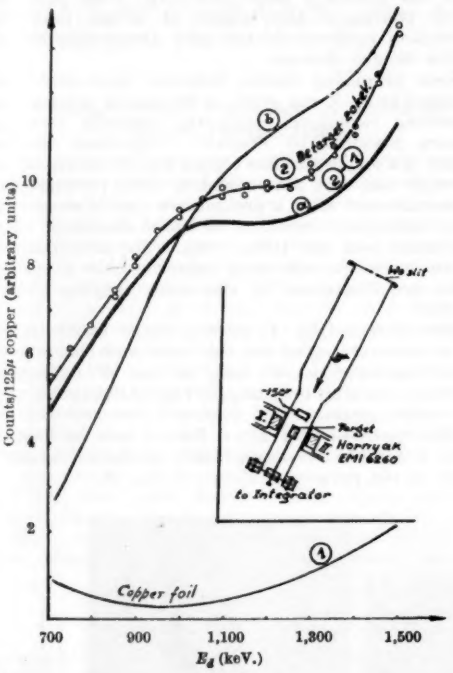

Fig. 1

Bombarding currents were measured by a new current integrator with low impedance input (precision better than 1·0 per cent)[2]. The deuteron beam was collimated with a tungsten foil slit[3]. Beryllium targets, 20–60 keV. thick, were prepared by evaporation of beryllium in high vacuum on to a copper foil of 0·05 mm. thickness. Target thicknesses were determined by weighing on a microbalance. Fig. 1 shows the measured excitation curve (*a*), together with the curve of Evans *et al.*[1] (*b*), taken at 0°. Resonance at 1,000 keV. is indicated by the shape of the curve. The mean values of counts of two detectors were always taken and the curve is a result of many repeated measurements.

Details of this work will be described in the *Bulletin of the Boris Kidrich Institute of Nuclear Sciences*, Belgrade.

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Amplification of 1-cm. Waves in the Helium Negative Glow

IN the course of detailed examination of the attenuation of microwaves in the negative glow of an abnormal discharge in helium, we have observed a negative attenuation. This occurs in a very narrow layer near the beginning of the negative glow and is a function of the gas pressure and the current density in the discharge tube.

A discharge tube 50 cm. long with two aluminium electrodes of 5 cm. diameter contained helium at pressures of 1–3 mm. mercury. A low-powered klystron beamed 1·25-cm. waves at right angles to the discharge tube with the electric vector of the waves parallel to the axis of the tube. The transmitted radiation was detected by means of a crystal detector and a sensitive galvanometer. Changes in attenuation were measured by means of a calibrated precision attenuator. The whole microwave assembly was carefully aligned and could be moved parallel to the discharge tube. The attenuation, because of the discharge, was measured at each position along the discharge tube as the difference in readings of the calibrated attenuator when the discharge was on and off.

Fig. 1 shows the attenuation in db./cm. as a function of the distance *d* from the cathode for a discharge current of 15 m.amp. and a pressure of 2·5 mm. mercury. Near the beginning of the negative

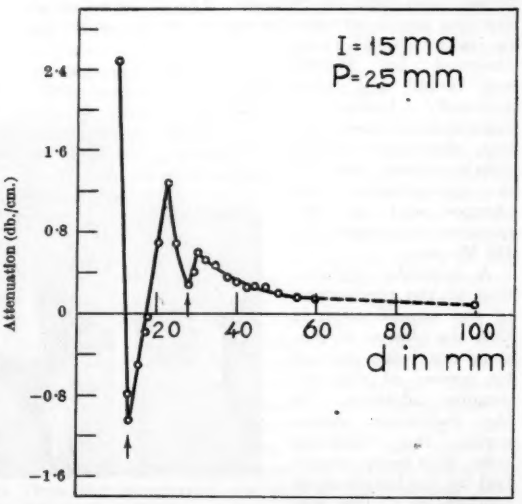

Fig. 1. Attenuation in db./cm. as a function of the distance *d* from the cathode

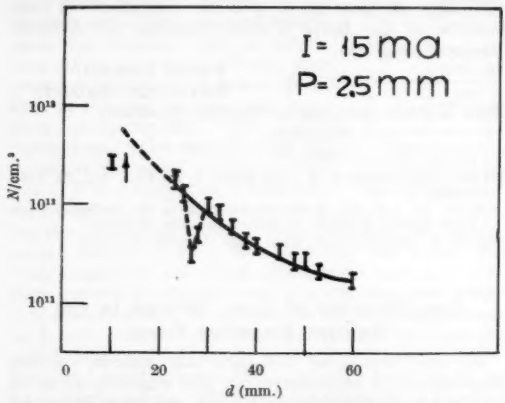

Fig. 2. Electron density as a function of the distance d from the cathode, calculated on the basis of a collision-frequency of $2{\cdot}3 \times 10^9 \times$ gas pressure in mm. mercury

glow, with d approximately 13 mm., we observed consistently a negative attenuation, or amplification, of the same wave-length in a very narrow layer. A secondary dip in the attenuation is found at about 27 mm. from the cathode. These changes are unlikely to be due to selective interference or diffraction effects because (*a*) they are independent of the distance of either the sending or receiving antenna from the discharge tube, and (*b*) no such effects are found when the polarity of the voltage is reversed.

If one assumes a collision-frequency of $2{\cdot}3 \times 10^9 \times$ gas pressure in mm. mercury for helium[1], one can readily calculate the electron density in the negative glow as a function of d. This is shown in Fig. 2. The extrapolation of this curve into the region of amplification indicates an electron density N of about 7×10^{12}/c.c. at d approximately 13 mm. The electron density calculated from the plasma frequency at 1·25 cm. is $7{\cdot}8 \times 10^{12}$/c.c., in close agreement. The secondary dip is at an electron density corresponding to a plasma frequency of about 2·5 cm.

The amplification increases with the current density and with the pressure. The observed amplifications are in very similar regions to the oscillations in narrow sheets observed by Merrill and Webb[2] and other authors[3–5]. Unlike our experiments, these violent oscillatory potentials have been observed in hot-cathode discharges and at frequencies not larger than 10^9 Mc./sec.

A possible explanation of the mechanism of the amplification is that the plasma oscillations are being excited by means of the impinging radiation. As the radiation passes across the discharge tube, it is being amplified by the longitudinal oscillations. The secondary dip is possibly due to the coupling of a harmonic of the plasma oscillations with the electromagnetic field.

The results of our experiments may have a bearing on the explanation of the propagation of solar and stellar radio waves and possibly on the practical application of amplification of microwaves of centimetre and millimetre wave-lengths.

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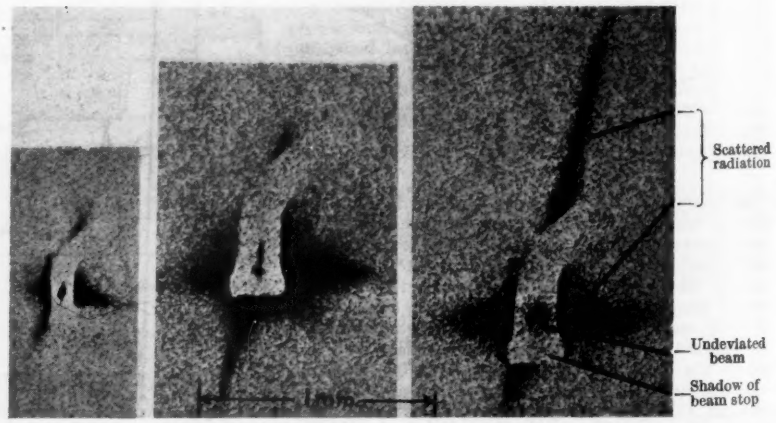
Investigation of the Fatigue of Metals by X-ray Scattering

It has generally been concluded[1] from previous X-ray studies of the fatigue of metals that the diffraction patterns do not give direct information of the fatigue damage.

Some promising results, however, have now been obtained in an X-ray study of fatigue by a low-angle scattering technique, using the optically focusing camera described by Franks[2]. Individual selected grains in a polycrystalline copper foil, the orientations of which had been determined by Laue photographs, were examined after a preliminary tensile stress and after subsequent amounts of cyclic stressing. The irradiated area was $100\mu \times 50\mu$. The modifications in the low-angle scattering patterns from a typical grain are illustrated in the accompanying photographs.

The pattern (Fig. 1) after a single tensile stress of 6 tons/in.[2], equal to the maximum loading in cyclic stressing, shows only a hint of diffraction streaks; but after fatiguing for 1 hr. (3,000 cycles/min. and mean stress of 3·2 tons/in.[2]), two streaks are readily apparent (Fig. 2). A further 1 hr. of fatigue, after which the specimen failed, produced enhancement of the pattern as shown in Fig. 3.



The enlargement of the reproductions is given by the scale. A smaller beam stop was used in Fig. 1

The streaks are due to scattering material of changed electron-density within the grain. A tentative interpretation suggests that they are caused by holes, their number, size and distribution changing with differing amount of fatigue. Patterns so far obtained suggest that the holes are disk-like in shape, with a diameter of the order of 100 A. Within the limits of experimental error, the holes lie on those {111} planes on which slip had taken place. It is suggested that the holes result from the plastic deformation within the grains caused by cyclic stressing, and that it is these holes which finally agglomerate to form a visible crack.

Further experiments are in hand to show whether the information obtained by this technique may be used as a criterion for estimating fatigue damage.

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Photochemical Processes in Solids at Room Temperature

Although this subject has received little study, the situation of the 'reactive sites' (excited molecules or free radicals) as 'embedded' in the solid matrix may be expected to lead to unusual kinetic effects. The molecular structure and close packing of the matrix should exert a profound effect on the collisional and energetic interactions of the reactive molecules. Phenomena such as energy transfer and Franck–Rabinowitch recombination should be most efficient in specific cases, although generally this may not be the case. Wilson[1], applying the Laplace transformation technique, has considered recently the interaction of diffusion and reaction kinetics for a series of theoretical cases. We report here some results of work with nylon polymer films, which have a bearing on this subject.

When thin nylon polymer films (approximately 20μ thick) are irradiated by an unscreened Hanovia *S*.250 *U* mercury arc in the presence of oxygen, a new absorption band develops centred around 2900 A., which shows the following unusual features, illustrated in Fig. 1. (1) If the incident radiation is cut off and the film stored in the dark, the band continues to increase in intensity with an initial rate greater than that immediately prior to storage. (2) The increase in the band intensity in the dark is found to be a constant fraction of the total intensity change, at all stages of reaction. (3) On re-irradiation the band intensity falls rapidly to a value corresponding to that immediately prior to the dark period; this 2900 A. band is quite clearly resolved and there is no suggestion from the spectra that a different product is formed in the dark from that in the light.

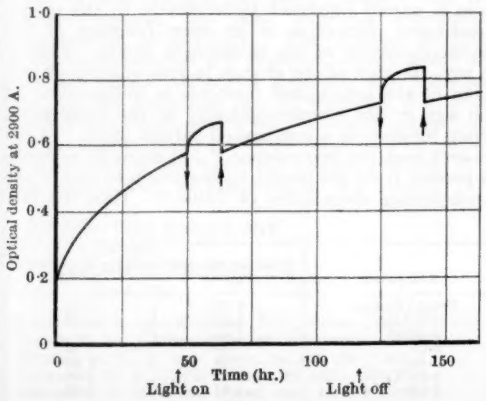

Fig. 1

The following simple reaction scheme can explain this behaviour:

$$\text{Nylon} \xrightarrow[k_1]{h\nu_1} B^{\cdot} + C^{\cdot}\,;\ k_1 I_1 \qquad (1)$$

$$B^{\cdot} + M \xrightarrow[k_2]{} BM\,;\ k_2\,[B^{\cdot}]\,[M] \qquad (2)$$

$$BM \xrightarrow[k_3]{h\nu_2} B^{\cdot} + M\,;\ k_3 I_2\,[BM] \qquad (3)$$

where I_1 and I_2 are the intensities at frequencies ν_1 and ν_2 respectively, $B^{\cdot}$ and $C^{\cdot}$ are free radicals, M is a molecular species (probably oxygen), and BM the product detected spectroscopically. The kinetics of such a system of consecutive reactions cannot be solved easily unless the simplifying assumption is made that the rate of primary photolysis is much slower than the other reactions involved. The system is then described as being in 'progressive equilibrium', for which the kinetics have recently been considered in some detail (Ford, R. A., unpublished work). In intermittent light a system of this type will show exactly the same characteristics as those found with the nylon films. Further, the kinetics lead to a relationship between rate and light intensity of the following type when I_1 and I_2 are increased in proportion:

$$\frac{1}{k_1 I_1} = \frac{1}{\mathrm{d}[BM]/\mathrm{d}t} - \frac{\omega}{K k_2}$$

where ω is I_2/I_1 and K is the equilibrium constant for reactions 2 and 3; thus there is a linear relationship between the reciprocal of the rate and the reciprocal of the light intensity, which is confirmed experimentally for the nylon films.

The characterization of the species BM is very difficult because of its instability and very low concentration. However, its sensitivity to light and the evidence of chemical analysis after prolonged irradiation, which shows photo-oxidation has occurred, have led us tentatively to assign the 2900 A. band to a peroxy radical, and therefore species M to the oxygen molecule. The reaction between a doublet organic radical and the $^3\Sigma$ ground-state of the oxygen molecule should give a doublet peroxy radical.

The prolonged existence of free radicals in a solid is to be expected, since termination rates will be so slow. Several workers[2] have observed such phenomena. Recently, Porter and Norman[3] have reported work in rigid glasses at 86° K., and Bijl and Rose-Innes[4] in 'Perspex' films at room temperature. Deoxygenated solvents were used for the rigid glass and the temperature was so low that chemical reaction other than photolysis was virtually ruled out. Thus the spectra of the simple free radicals were detected. However, our results suggest that for solids at room temperature rapid diffusion of oxygen

will result in only the oxygenated radical being detected. This was probably the case in work by Bijl and Rose-Innes.

It therefore appears that the diffusion processes in solids may be separated kinetically into two classes with rates of a very different order: (1) very slow diffusion of organic free radicals and their oxygenated derivatives; (2) much more rapid gaseous diffusion. The effects described by Wilson[1] appear likely to occur only in the case of the former processes.

If this unusual behaviour in nylon films is due to oxygenated radicals, one would expect it to be a fairly general phenomenon, although it may be unique for solids since a rigid medium is necessary to prevent processes of radical termination. Similar effects have been reported for polystyrene by Reiney *et al.*[5]. But it was then thought that a different product was obtained in the dark from that in the light, and therefore their results were interpreted differently. However, no new band was clearly resolvable in their spectra, which leaves their interpretation open to doubt.

I wish to acknowledge an interesting discussion with Dr. E. J. Bowen, and the permission of British Nylon Spinners, Ltd., to publish this communication.

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A Simplified Method of preparing Pure Mono-, Di- and Tri-glycerides

Glycerides of known structure are usually prepared by blocking one or two hydroxyls of glycerol and esterifying the remaining hydroxyl or hydroxyls with fatty-acid chlorides. Thus monoglycerides are obtained by the action of a fatty-acid chloride on acetone–glycerol according to the well-known method of Fischer *et al.*[1], whereas mixed di- and tri-glycerides have been synthesized by Verkade and co-workers[2] by the use of triphenyl-chloro-methane.

However, the greater reactivity of primary hydroxyls of glycerol, as compared with that of secondary hydroxyl, makes possible a selective esterification without recourse to blocking. This technique has been employed to a limited extent in the past[3]. Selective esterification has now been developed in this laboratory into a general method covering the whole range of glyceride syntheses. One of the difficulties has been to bring into a homogeneous solution glycerol, fatty-acid chlorides and chloroform (used commonly as solvent in such reactions). The difficulty has been overcome by the addition of N,N-dimethyl formamide, which ensures the miscibility of glycerol with other components.

Monoglycerides can now be prepared directly from fatty-acid chlorides and a large excess of glycerol (5–10 mol. of glycerol per 1 mol. of fatty-acid chloride). To obtain monoacid $\alpha\alpha'$-diglycerides, 1 mol. of glycerol is esterified with 2 mol. of a fatty-acid chloride in a single step. In both cases sufficient dimethyl formamide is employed to obtain a homogeneous mixture at about 10° C., with pyridine as catalyst. Diacid diglycerides are produced in the reaction between a monoglyceride and another fatty-acid chloride used in approximately equimolar proportions. By extending this procedure to the preparation of mixed triglycerides, all three isomers of triglyceride containing stearic, palmitic and oleic acid radicals have been obtained in good yields by three-stage direct esterification. Their characteristics conformed with those of the triglycerides synthesized by Prof. P. E. Verkade[4], who kindly supplied samples of his products. Although Fischer's and Verkade's methods have been indispensable in establishing the configuration and properties of synthetic glycerides, for preparative purposes selective direct esterification of glycerol might be useful.

It is hoped to publish experimental details of this work elsewhere.

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Molecular Orbital Theory of the Relative Reactivities of Substituted Aromatic Molecules towards Radical Addition

The results obtained recently by Farenhorst and Kooyman[1] on the relative reactivities of substituted anthracenes towards radical attack lend support to the validity of the simple molecular orbital theory of radical reactions. The results show (Table 1) that substitution at the 9-position enhances the activity towards radical attack at the 10-position irrespective of the polarity of the substituent group.

Two theoretical criteria have been used for the description of radical reactions: first, the free valence F_r at atom r in the unperturbed ground-state[2], and secondly the radical localization energy ΔE_r required to localize a free electron at position r, calculated according to the technique introduced by Wheland[3]. Now it has been shown[4] that in the simplest molecular orbital theory the change in free valence δF_r in passing from a parent alternant hydrocarbon to the monosubstituted derivative is an even function of the electronegativity of the substituent group. That is to say, the sign of the change in free valence at any atom of the conjugated molecule is independent of the sign of the electronegativity of the substituent group referred to a conjugated carbon atom. In the present case, the free valence F_{10} at atom 10 increases in passing from the parent hydrocarbon to any of the 9-substituted derivatives of Table 1. Thus the pre-

Table 1

Anthracene	Relative rate-constants for 10-position 55° C.	70° C.
Unsubstituted	1·00	1·00
9-Methyl	2·06	2·06
9-Ethyl	1·48	—
9-Cl	1·64	1·62
9-Br	1·33	1·28
9-OCH$_3$	2·09	2·06
9-CN	4·24	3·94

dicted increase in free valence is paralleled by the observed increase in activity of the 10-position.

Similarly, it has been shown[3] that the change in localization energy ΔE_r in passing from the parent hydrocarbon to the monosubstituted derivative is also an even function of the electronegativity of the substituent group. In the present case, the localization energy ΔE_{10} at atom 10 is reduced in passing from the parent hydrocarbon to all 9-substituted derivatives. Again, the observed increased activity at the 10-position parallels the predicted reduced activation energy.

To emphasize the significance of these results, it may be pointed out that, for example, the charge density q_{10} (which is used as an index for ionic reactivity) at atom 10 would increase for 9-substituents less electronegative than carbon and decrease for those more electronegative. Similarly, the localization energy for electrophilic attack at the 10-position would decrease for 9-substituents less electronegative than carbon and increase for those more electronegative. These quantities are, in fact, odd functions of the electronegativity at the position of substitution[4,5]. It may be noted that the dependence upon electronegativity in the treatment described here is deduced analytically, and the result is free from the usual arbitrary choice of parameter.

The new experimental results bear out the earlier work of Hey and Williams[6] on radical attack upon benzene derivatives, which also support the simple molecular orbital theory in that the effect of various substituent groups is independent of their polarity. There exists, however, one interesting anomaly. The simple theory predicts an increase in free valence at the *ortho*- and *para*-positions and a decrease at the *meta*-position for all substituents[3]. Hey and Williams have found, however, that all three positions are activated, except in the case of pyridine, which manifested an increased relative rate factor in the α- and γ-positions and a decreased value in the β-position. There are good reasons for believing that the simple theory, which represents the effect of a substituent by a change of coulomb integral at the position to which it is attached, reproduces adequately the perturbation produced in the charge distribution at positions for which the effect is not small, provided electron-attracting groups are represented by an increase in electronegativity, and electron-donating by a decrease, at the position of attachment. The signs of the changes in charge density and free valence, indeed, are then correctly represented (unpublished calculations). The changes produced at the meta-position are, however, always small, and here the simple theory is generally not adequate. But for the particular case of pyridine, the hetero atom N is coincident with the position of substitution and the simple theory is strictly valid. It is interesting to note that in this case[6] the β(*meta*)-position is, in fact, deactivated, as predicted by the theory.

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Adsorption of Methylene Blue by High-Silica Sands

HIGH-SILICA sands from which the intergranular material has been washed away have been found to adsorb considerably more methylene blue per unit of superficial surface as determined by the air permeability method[1] than was adsorbed by crushed quartz crystal. A sample of the latter material (from B.D.H.) took up $1{\cdot}2 \times 10^{-4}$ mgm. of dye per sq. cm. superficial surface, and this figure agrees well enough with that calculated by Gaudin and Rizo Patrón[2] for the adsorptive capacity of a quartz surface for positive ions to suggest that the surface accessible to methylene blue was very nearly the same in extent as the superficial surface for this material. The same was not true of most sand samples. Values for the surface accessible to methylene blue calculated from the figure obtained for crystal quartz were found in some instances to be many times the superficial surface.

Sixty-five samples from forty-five localities, eight of them outside the British Isles, have been examined. Forty-eight of the samples had values of between 2 and 5 for the ratio superficial to accessible surface, eleven had ratios greater than 5, and the remainder had ratios less than 2. The extreme range was about 0·5–15·9.

From the following evidence the adsorptive layer seems to consist of finely divided silica, that is, the grain surfaces are involuted to a greater or lesser extent. (1) 40 per cent hydrofluoric acid reduced the adsorptive capacity to a very low figure, and a marked reduction was effected by solutions containing as little as 0·1 per cent hydrogen fluoride. (2) *N* sodium hydroxide reduced the adsorptive capacity of all but one of the samples examined; subsequent washing with dilute acid to remove any adsorbed sodium ions did not increase the adsorption of dye. (3) Attrition and comminution reduced the ratio of superficial to accessible surface. (4) Sand coated artificially with Fe_2O_3 or Cr_2O_3 adsorbed very little methylene blue.

That the adsorptive layer did not consist of silicic acid[4] or hydrated silica seems to be proved by the behaviour of the sands on ignition at 700° C. Nineteen samples were ignited, and of these, eleven showed reduction in adsorptive capacity (which could be attributed to sintering of surface impurities), three were unchanged, and five adsorbed more dye than previously.

Sands which were strongly stained with iron generally adsorbed most dye, and rather surprisingly the adsorptive capacity was not increased by extraction with 11 *N* hydrochloric acid, except in a few cases. Of twenty-six samples extracted, only four adsorbed more dye after treatment, fourteen adsorbed less, and the remainder were unchanged. Most of the sands carried Fe_2O_3 or Al_2O_3 on the surface of the silica grains. Al_2O_3 was detected, on the paler sands, by the pink colour obtained with aurine tricarboxylate[3].

It does not seem possible to account for the reduction in adsorptive capacity after acid treatment by assuming that hydrogen ions were taken up from the acid solution and so prevented subsequent adsorption of methylene blue[3]. Samples which had been extracted with hydrochloric acid and then ignited at 500° C. showed no regular change in adsorptive capacity. Of eight samples so treated,

two showed a slight increase, two were unchanged, two showed a slight decrease, and two showed a marked decrease. It seems reasonable to suppose that adsorbed hydrogen ions would be driven off below 500° C., with a consequent increase in adsorptive capacity for methylene blue.

We are led to conclude that the observation that acid extraction does not in general lead to increased dye adsorption must be accounted for by the inaccessibility to methylene blue ions of the sites occupied by the basic compounds on the silica surface. The reduction in adsorptive capacity observed in many cases may arise from disruption of capillaries adjacent to the positions occupied by the basic compounds, or of capillaries of which these latter form structural units, leading to a general 'smoothing out' of the surface.

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Radioactivation Analysis of Phosphorus in Silicon

In a previous communication[1], a radioactivation method for the determination of arsenic in 'high purity' silicon was outlined. Further work on trace impurities in this element has resulted in the development of a technique for estimating submicrogram quantities of phosphorus.

On irradiating a silicon sample with thermal neutrons, the following reactions take place.

$$^{30}\mathrm{Si}\ (n\gamma)\ ^{31}\mathrm{Si} \xrightarrow{\beta'} {}^{31}\mathrm{P} \quad t_{\frac{1}{2}} = 2{\cdot}62\ \mathrm{hr.} \qquad (1)$$

$$^{31}\mathrm{P}\ (n\gamma)\ ^{32}\mathrm{P} \xrightarrow{\beta'} {}^{32}\mathrm{S} \quad t_{\frac{1}{2}} = 14{\cdot}3\ \mathrm{days} \qquad (2)$$

It can be seen that phosphorus atoms are produced by the decay of silicon-31 and that these are then activated according to equation (2). As these phosphorus-31 atoms are produced exponentially during irradiation, they are subjected to varying irradiation times and so the activity they produce, when extrapolated to zero time, merely indicates an apparent phosphorus concentration. The following expression has been derived for this concentration:

$$C_{^{31}\mathrm{P}} = \frac{6\varphi\sigma T \times 10^{5}}{0{\cdot}69\ N} \left\{ \frac{0{\cdot}69\ T_0}{(1-\exp -0{\cdot}69\ T_0/T)T} - 1 \right\}$$

in parts per million (3)

where φ is neutron flux, σ is cross-section of silicon-30 (barns), T is half-life of phosphorus-32 (sec.), T_0 is irradiation time (sec.), and N is Avogadro's number.

The above relationship indicates that the apparent phosphorus concentration varies as the neutron flux and irradiation time, so that irradiation conditions for phosphorus in the submicrogram range must be carefully chosen to give optimum analytical conditions. We have selected an irradiation time of one week at a pile factor of ten for routine determinations, when equation (3) gives 0·0011 p.p.m. of apparent phosphorus, although under these conditions the total phosphorus-31 impurity introduced into silicon by radioactivation is 0·0024 p.p.m. ($4{\cdot}7 \times 10^{18}$ atoms/gm. silicon).

We have used the following method for separating the active phosphorus chemically. Sufficient time is allowed to elapse after irradiation for the silicon-31 activity to have decayed to a negligible amount (one to two days for a sample of 0·5–1 gm.). The silicon is slowly dissolved in a hydrofluoric–nitric acid mixture with disodium hydrogen phosphate present as carrier, the rate of reaction being controlled by addition of nitric acid. After complete removal of the silicon as the gaseous silicon tetrafluoride, the solution is reduced to small bulk, perchloric acid is added and taken to fuming to remove hydrogen fluoride. Dilute hydrochloric acid is added to the solution and the phosphate present is precipitated as $MgNH_4PO_4.6H_2O$ with magnesia mixture and ammonia in the usual way[2]. After standing for 24 hr. the precipitate is filtered, washed and redissolved with dilute hydrochloric acid. The magnesium ammonium phosphate is again brought down as before but in the presence of citric acid, and the whole is allowed to stand for a further 24 hr. It is then centrifuged, washed and slurried into a crucible and ignited at 1,100° C. to constant weight. The $Mg_2P_2O_7$ thus formed is finely ground and transferred to a counting tray to be counted and weighed.

Red phosphorus and disodium hydrogen phosphate were tried as standards. Known amounts were sealed in silica ampoules and irradiated with the silicon samples. They were dissolved and the phosphate extracted as already described. Although agreement was obtained between the two standards, disodium hydrogen phosphate was selected as the more suitable due to its higher purity and to the ease with which it could be dissolved.

Samples of 'pure' silicon from various sources, for use in semi-conductor devices, have been examined by this technique and found to contain phosphorus impurity ranging from 2·0 to 0·004 p.p.m. The distribution of phosphorus within a 'doped' single crystal has also been investigated by this method, and the results obtained are consistent with published segregation coefficients[3], conductivity and autoradiographic measurements.

We wish to acknowledge helpful discussions with colleagues in this Laboratory, especially Mr. R. H. A. Crawley.

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Alpha-Oxidation of Omega-(2 : 4-Dichlorophenoxy)alkanenitriles and 3-Indolylacetonitrile within Plant Tissues

Biological and chemical investigations carried out here on the plant growth-regulating activity of ω-aryloxyalkanecarboxylic acids have established the importance of β-oxidation as a mechanism by which these acids are degraded in plants[1]. As a logical extension of this work, the corresponding nitriles were

prepared and examined in the wheat cylinder elongation test (Table 1, Fig. 1) and pea curvature test (Table 1). Extracts of the wheat and pea tissues and of the solutions used in these tests were then separately examined by paper chromatography in the descending manner using butanol/ammonia/water (200 : 6 : 36 at 20° C.). The chromatograms were divided transversely into ten equal segments and each was assayed for growth-regulating activity by the wheat test. Authentic 2 : 4-dichlorophenoxyacetic acid was also run in each experiment. By such means it was possible to correlate activity of the substance originally tested with the production of the dichlorophenoxyacetic acid, a compound highly active in the wheat cylinder test. In every instance where growth-regulating activity was shown, chromatographic evidence for degradation of the compound to 2 : 4-dichlorophenoxyacetic acid was obtained. Thus, when the homologous series of acids used in these experiments ($RO(CH_2)_nCOOH$) was treated with both wheat and pea tissue, an alternation in activity associated with β-oxidation[1] was accompanied by the appearance of 2 : 4-dichlorophenoxyacetic acid when n was 1, 3 and 5.

The nitrile series, $RO(CH_2)_nCN$, however, behaved quite differently. Thus, in the pea test, only 2 : 4-dichlorophenoxyacetonitrile ($n = 1$) was active and this correlated with the production of the corresponding acid. No activity was shown in the pea test by any of the higher homologues, and this was in agreement with the fact that no 2 : 4-dichlorophenoxyacetic acid was found in solutions of these compounds treated with pea tissue. In view of the inactivity of those members where n is 3 or 5, it would seem that the —CN → —COOH conversion does not readily occur in these higher nitriles in presence of pea tissue.

In the wheat cylinder test, all members of the nitrile series showed significant activity (Fig. 1), and 2 : 4-dichlorophenoxyacetic acid was produced in all cases in amounts corresponding to their activities. Acid production is readily explicable in the alternate homologues ($n = 1$, 3 and 5) in terms of hydrolysis followed by β-oxidation; but the production of the acid from other members of the nitrile series ($n = 2$, 4 and 6) must involve a type of side-chain breakdown not hitherto recognized in plant biochemistry. The

Table 1. Growth-regulating Activity in Two Tests of ω-(2 : 4-Dichlorophenoxy)alkane-Carboxylic Acids, $RO(CH_2)_nCOOH$, and Nitriles, $RO(CH_2)_nCN$

n	Wheat cylinder elongation test*		Pea curvature test*	
	Acids	Nitriles	Acids	Nitriles
1	Active†	Active†	Active†	Active†
2	Inactive	Active†	Inactive	Inactive
3	Active†	Active†	Active†	Inactive
4	Inactive	Active†	Inactive	Inactive
5	Active†	Active†	Active†	Inactive
6	Inactive	Active†	Inactive	Inactive

* Within concentration range of 0·01–10 p.p.m.

† 2 : 4-Dichlorophenoxyacetic acid detected by paper chromatography and bioassay.

fact that β-(2 : 4-dichlorophenoxy)propionitrile ($n = 2$) is partially converted to 2 : 4-dichlorophenoxyacetic acid shows that a one-carbon fragment can be lost. A similar degradation in the other nitrile homologues with $n = 4$ and 6, followed by β-oxidation, would explain the production of the 2 : 4-dichlorophenoxyacetic acid in these cases.

In a parallel investigation we have studied the breakdown of 3-indolylacetonitrile within pea and wheat tissue using similar chromatographic techniques. The negligible activity of this compound in the pea test was consistent with the absence of 3-indolylacetic acid on the chromatogram, a result in agreement with the work of Thimann[2]. On the other hand, it was readily detected on the chromatogram from the wheat cylinder test, in which the nitrile was highly active. The presence of 3-indolylacetic acid was proved by its R_F value, bioassay, and the production of distinctive colours with Ehrlich and other reagents. In all experiments where pea or wheat tissues were treated with the nitrile, however, the chromatogram showed a distinct red spot of $R_F = 0{\cdot}12$ when sprayed with Ehrlich reagent followed by concentrated hydrochloric acid. This new compound was shown to be an acidic substance, inactive in both the wheat and pea tests, and it possessed the same R_F values (0·12 in butanol/ammonia/water; 0·20 in *iso*propanol/ammonia/water) as 3-indolylcarboxylic acid. When run mixed with an authentic specimen of this substance, a single spot was obtained. Further evidence of its identity was provided by ultra-violet absorption spectra measurements kindly carried out for us by Prof. E. A. Braude.

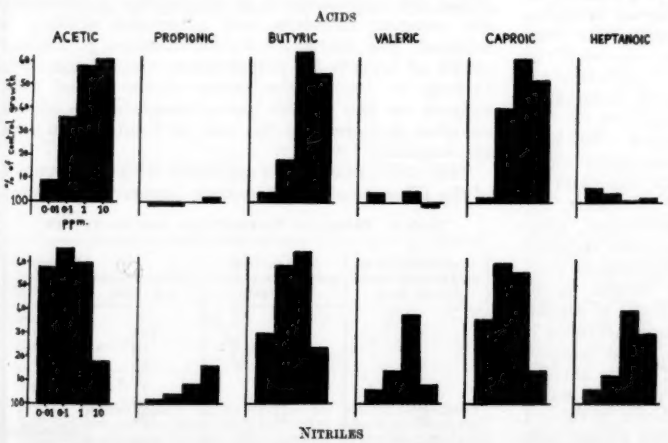

Fig. 1. Growth-regulating activity in the wheat cylinder elongation test of ω-(2 : 4-dichlorophenoxy)alkane-carboxylic acids, $RO(CH_2)_nCOOH$, and nitriles, $RO(CH_2)_nCN$

In view of the above findings, it was reasonable to expect 3-indolylcarboxylic acid to be present in some of the plant tissues where the acetonitrile occurs naturally. Other chromatographic studies carried out here by Dr. P. M. Cartwright have, in fact, revealed that 3-indolylcarboxylic acid is present with a substance suspected to be 3-indolylacetonitrile in germinating peas.

The conversion of 3-indolylacetonitrile to 3-indolylcarboxylic acid in pea and wheat tissue represents a similar type of degradation, $—CH_2CN \rightarrow —COOH$, to that indicated in the phenoxy nitrile experiments discussed above. In both cases the loss of a one-carbon fragment occurs. Since the α-methylene

group becomes converted to carboxyl, the process may be regarded as one of α-oxidation. Various mechanisms by which such conversions may take place are now being studied. The results of preliminary experiments on the behaviour of the corresponding amides both in the phenoxy and indole series indicate that the amide is not an important intermediate product in such α-oxidation.

The possibility that aliphatic nitriles may be metabolized in the animal body by a mechanism involving oxidation of the α-methylene group arises from the work of Lang[3] and Adeline[4]. More recent work of Pattison[5] on the toxicity to rats of ω-fluoroalkylnitriles provides further evidence of such breakdown. Thus, in the animal there is evidence that certain nitriles may be metabolized by a process of α-oxidation followed by β-oxidation of the resulting acid. The present work indicates that a similar sequence of breakdown reactions may occur in plant biochemistry.

These results will be published in detail elsewhere.

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Inhibition, Restoration and Enhancement of Proteolytic Action by Polylysine and Polyglutamic Acid

Polyelectrolytes of high molecular weight have been shown to inhibit a variety of enzymes in what Spensley and Rogers[1] have called macroanionic and macrocationic inhibition. This phenomenon is probably due to an interaction of the polyelectrolytes with the enzyme or the enzyme-substrate complex. The inhibition of pepsin by the polypeptide polyelectrolyte poly-L-lysine has been reported by Katchalski, Berger and Neumann[2]. Polylysine has been shown to combine reversibly with albumin to form insoluble complexes which dissolve in the presence of excess of either component[3]. We have also studied the inhibition of the proteolytic action of pepsin by the macrocation, poly-L-lysine, and the reversal of this inhibition by excess polylysine, and the inhibition of trypsin by the macroanion, polyglutamic acid, as well as the restoration and enhancement of trypsin action by excess polyglutamic acid.

Poly-L-lysine (average molecular weight 2,100) was added to pepsin (25γ per ml.) in 0·001 *M* acetate buffer at *p*H 4·7 and the per cent transmittance of the solution was determined at 400μ. The complex was then added to the substrate and peptic activity determined by the method of Anson[4]. The results obtained from these experiments are shown in Table 1.

Poly-L-lysine was observed to inhibit pepsin completely at low concentrations, but at higher concentrations of the peptide, 98 per cent of the original enzymatic activity was restored. At the same time, it was observed that polylysine and pepsin formed insoluble complexes at low concentrations of the polyelectrolyte, which dissolved when the concentration of the peptide was increased. Addition of the peptide to the substrate rather than to the enzyme did not inhibit the proteolytic activity of pepsin.

Table 1. Effect of Poly-L-lysine on Pepsin

Concentration of poly-L-lysine (γ per ml.)	Mole ratio of poly-L-lysine to pepsin	Transmittance (per cent)	Inhibition (per cent)
0	—	100	0
1·56	1	98	0
2·1	1·5	56	0
3·12	2·2	77	12
6·25	4·4	98	100
12·5	8·8	99	100
25	17·5	99	98·5
50	35	99	46·5
100	72·5	100	29·5
200	150	100	2·4

The inhibition of trypsin (100γ per ml.) by the macroanion, polyglutamic acid (average molecular weight 2,580), was carried out in much the same manner as the inhibition of pepsin by poly-L-lysine except that phosphate buffer 0·005 *M* at *p*H 7·5 was used. The per cent transmittance of the solution was again determined at 400μ, and the tryptic activity was followed by the method of Anson[4]. Polyglutamic acid was found to inhibit the proteolytic action of trypsin at low concentrations, whereas at higher concentrations of this peptide the activity was not only restored but also greatly increased. At the highest concentration of peptide used, a molecular ratio of 52 to 1, the activity of trypsin was increased almost three-fold. An insoluble complex was shown to form at low concentrations of polyglutamic acid; this precipitate dissolved when the concentration of the peptide was increased. A summary of the results obtained is shown in Table 2.

The inhibition of the two enzymes is similar, and it is probable that a common mechanism exists for both cases. At low concentrations of the peptide, the enzyme and the peptide must combine, probably due to electrostatic attraction, to form complexes which aggregate to give the precipitates. Inhibition may then be due to either the masking of the active site of the enzyme or the precipitation of the enzyme. When the concentration of the peptide is increased, the complex dissolves and enzymatic activity is restored. The mechanism for the enhanced proteolytic action of trypsin by polyglutamic acid is unknown. It may be due to the action of the added ionic charges on the soluble polyglutamic acid – trypsin complex in increasing the rate of combination with the substrate.

This communication is published with the approval of the Director of the Wisconsin Agricultural Experi-

Table 2. Effect of Polyglutamic Acid on Trypsin

Concentration of polyglutamic acid (γ per ml.)	Mole ratio of polyglutamic acid to trypsin	Transmittance (per cent)	Change in activity (per cent)
			Inhibition
0	—	100	0
1·3	0·4	76	70
3·6	0·8	48	75
6·25	1·6	50	80
12·5	3·2	77	80
25	6·4	100	85
50	13	100	75
			Activation
100	26	100	250
200	52	100	290

ment Station. The work was supported in part by a research grant from the Herman Frasch Foundation.

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Effect of 2,4-Dichlorophenoxyacetic Acid and Maleic Hydrazide on Potato Proteins as shown by Paper Electrophoresis

PREVIOUS studies[1] have shown that 2,4-dichlorophenoxyacetic acid increases the total protein content in potato tubers and that maleic hydrazide upsets cell-division in the meristematic zone in tuber eyes[2]. The present work was concerned with changes in potato tuber proteins, resulting from plant spray treatments with 2,4-dichlorophenoxyacetic acid (2,4-D), maleic hydrazide, and a combination of the two chemicals. Analyses were made immediately after harvest and after sixty days storage.

Potatoes used in this experiment were of the Red McClure variety, grown at the San Luis Valley Experimental Farm near Center, Colorado, during the 1953 season. There were four plots, each replicated three times. Treatments were as follows: (1) maleic hydrazide (*MH*–40, U.S. Rubber Co.) at 3 lb. per acre active ingredient; (2) alkanolamine salts (ethanol and *iso*propyl series) of 2,4-dichlorophenoxyacetic acid (Dow Chemical Co.) at 0·5 lb. per acre, acid equivalent; (3) alkanolamine salt of 2,4-dichlorophenoxyacetic acid at 0·5 lb. per acre plus maleic hydrazide (*MH*–40) at 3 lb. per acre sprayed 24 hr. apart in that order; (4) control, no treatment.

The treatments were applied as plant sprays when the tubers were about ¾ in. in diameter. At harvest, tubers were selected at random from each treatment and frozen. Comparable samples were stored for sixty days in a potato cellar (average temperature 40° F.), after which they were also frozen. The tubers

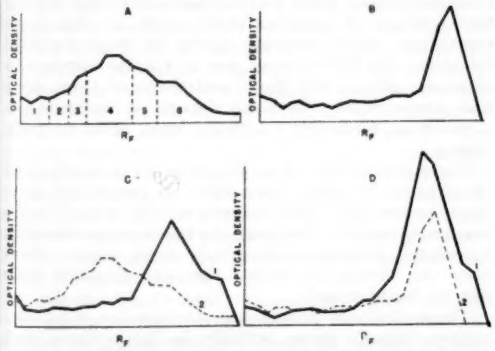

Fig. 1. Optical density curves showing the protein fractions in Red McClure potato juice. (*A*) Untreated sample showing six probable fractions at harvest. (*B*) Untreated sample after 60 days of storage. (*C*,1) Sample treated with 2,4-D; at harvest. (*C*,2) Untreated sample at harvest. (*D*,1) Sample treated with 2,4-*D*; after 60 days storage. (*D*,2) Untreated sample after 60 days storage

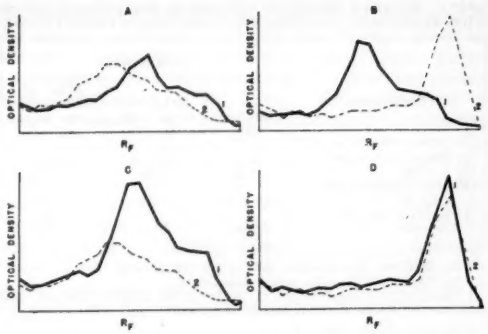

Fig. 2. Optical density curves showing the protein fractions in Red McClure potato juice. (*A*,1) Sample treated with maleic hydrazide at harvest. (*A*,2) Untreated sample at harvest. (*B*,1) Sample treated with maleic hydrazide; after 60 days storage. (*B*,2) Untreated sample after 60 days storage. (*C*,1) Sample treated with maleic hydrazide and 2,4-D at harvest. (*C*,2) Untreated sample at harvest. (*D*,1) Sample treated with maleic hydrazide and 2,4-D; after 60 days storage. (*D*,2) Untreated sample after 60 days storage

from each sample were allowed to thaw and the juice was concentrated to one-fifth its original volume by lyophilization.

A Wieland-type of instrument modified by Grassmann and Hannig[3] was used for producing zone electrophorograms. Cacodylic buffer of *p*H 6·93 (above the isoelectric point of the potato protein) was used in the instrument. The ionic strength was 0·1. A 0·02-ml. aliquot of concentrated juice was pipetted on a buffer-dampened filter-paper strip (Whatman No. 1), 1¼ in. wide. The instrument was run for six hours at 300 V., 5 m.amp., after which the paper strips were taken out and dyed in amido-black 10*B* (Farbenfabriken Bayer, Leverkusen, Germany) for 10 min. Upon coming out of this bath, the strips are dyed a dark colour. Three 10-min. baths of 5 per cent phenol were used to de-stain the strips of paper, followed by fixation in 10 per cent concentrated glacial acetic acid in absolute methanol.

The relative amounts of proteins in the tuber juices were measured by a densitometer (Welch and Co., 'Densichron') using the electrophorograms. Since the amido-black stains proteins proportionately to the concentration, the optical density curves were plotted for each treatment. The total area (proteins) under the curves was measured with a planimeter in square inches.

A typical optical density curve for each of the four treatments is shown in Figs. 1 and 2. The dotted line in all cases represents the untreated samples. Six probable protein fractions appeared in the electrophorograms of the untreated samples (Fig. 1,*A*). After sixty days of storage (Fig. 1,*B*) the main protein fraction decreased and the fastest-travelling fraction increased. Groot *et al.*[4], using a Tiselius electrophoretic apparatus, showed there were two protein fractions in potato juice. The main fraction was a globulin known as tuberin and a second fraction was called tuberinin. A third fraction was suggested but was not named. In 1953, Schwarze[5] used paper electrophoresis and obtained one large and four smaller bands, a total of five different protein fractions. Fig. 1,*A* shows six fractions. The sixth one is probably the unnamed protein suggested by Groot, and may be part of the wide band shown by Schwarze. A similar change occurred at harvest in the samples treated with 2,4-dichlorophenoxyacetic acid (Fig. 1,*C*) and after storage (Fig. 1,*D*). Maleic

Table 1. Relative Amount of Proteins in Red McClure Potato Juice, Measured by the Areas under the Optical Density Curves

Treatments	Total protein		
	Rate/acre (lb.)	At harvest (area units, sq. in.)	After 60 days storage (area units, sq. in.)
(1) Maleic hydrazide*	3·0	2·61‡	1·66
(2) 2,4-D†	0·5	2·68	2·71
(3) Maleic hydrazide + 2,4-D	3·0 + 0·5	3·23	2·26
(4) Control, no treatment	none	2·10	2·28

* As *MH*–40, the sodium salt, active ingredient.
† As alkanolamine salt, active ingredient.
‡ Planimeter measurements of areas under density curves; each value is the mean of six different samples.

hydrazide produced very little change at harvest (Fig. 2,*A*) but appeared to prevent the shift after storage (Fig. 2,*B*) which occurred in the controls. This failure to change in the maleic hydrazide samples may be the basic reason why maleic hydrazine prevents sprouting, whereas 2,4-dichlorophenoxyacetic acid (at 0·5 lb. per acre) does not prevent sprouting in potatoes. Combination effects (Fig. 2,*C* and *D*) resembled those of 2,4-dichlorophenoxyacetic acid used alone.

The relative amount of proteins in the tuber juice, as measured by the areas under the optical density curves, is shown in Table 1.

The results indicate that all three treatments increased the total protein in potato tubers, as compared to the untreated sample, based on protein analysis immediately after harvest. The greatest increase resulted from the combination treatment. After sixty days of storage, the maleic hydrazide decreased, and the 2,4-dichlorophenoxyacetic acid increased, the total protein as compared to the control. The combination treatment produced little change on the total protein. As indicated in an earlier paper[1], this study has further substantiated the fact that treatment of Red McClure potato plants prior to harvest with 2,4-dichlorophenoxyacetic acid increases the protein content of the tubers.

This work was supported in part by a research grant from the Herman Frasch Foundation.

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Growth of Sarcoma 37 Mouse Ascites Tumour in Peritoneal Fat

There are no previous reports that ascites tumours grow in or on tissues before fluid and cells increase in the peritoneal cavity. Therefore, it is thought to be of interest to present evidence that such growth takes place in peritoneal fatty tissue.

In early passages of a sarcoma 37 mouse ascites tumour, histological sections invariably showed sarcomatous infiltration of peritoneal fatty tissue. Afterwards similar infiltration was revealed before ascitic fluid had accumulated. As a result of these findings an experiment was carried out in which 3·1 million sarcoma cells were inoculated intraperitoneally into male mice that were killed at intervals after inoculation. The peritoneal fluid was collected and measured; if the amount was less than 0·1 ml. it was recorded as such. The sarcoma cells in the fluid were counted in a hæmocytometer and recorded in millions per ml. From these results the total number of sarcoma cells in each peritoneal fluid was estimated. Histological sections were prepared from the fatty tissue in the peritoneum between the stomach and spleen and from the bodies of fat attached to the gonads. The results are shown in Table 1.

Table 1. Increase of Sarcoma Cells and of Fluid in the Peritoneal Cavity and Infiltration of Peritoneal Fat after Intraperitoneal Inoculation of Male Mice with 3·1 Million Sarcoma Cells

Time after inoculation in hr.	No. of mice	No. of mice with 0·1 ml. or more of fluid	Total sarcoma cells in millions	No. of mice showing sarcoma cells in fat
6–10	5	0	Av. < 2·9 Range < 2·4 to < 3·5	5
18–22	4	0	Av. < 2·5 Range < 2·2 to < 3·0	4
30–48	6	2	Av. < 6·8 Range < 3·6 to 11·6	6
72	3	3	Av. 11·2 Range 9·6 to 12·1	3

It can be seen that during the first twenty-two hours there is no significant increase in the number of cells over those inoculated and no accumulation of peritoneal fluid. During the first period (6–10 hr.) it was necessary to examine many sections from each mouse; but, in some sections from each, sarcoma cells could be recognized within the fatty tissue itself by their very large size, basophilic cytoplasm and large vesicular nucleus. Some cells could be seen applied to blood vessels, some to fat cells and some were in mitosis. In sections removed from mice killed between 18 hr. to 22 hr., sarcoma cells were more numerous, sometimes occurring in groups replacing fat cells. Between 30 hr. and 48 hr. there appeared to be an increase in the total number of cells in the peritoneal fluid, and two of the six mice had more than 0·1 ml. of fluid. Sections showed that groups of sarcoma cells were in the fatty tissue and small vascular sheets of them replaced fat cells. At 72 hr. there was a definite increase in sarcoma cells in the fluid, and three of three mice had excess fluid. Sections showed vascular sheets of sarcoma replacing relatively large areas of fatty tissue.

These results show that invasion and multiplication of sarcoma 37 cells takes place in peritoneal fatty tissue before there is an increase of cells or fluid in the peritoneal cavity. This suggests that intraperitoneally inoculated sarcoma cells invade fatty tissue, where they can obtain nutriment for multiplication from nearby blood vessels.

These findings permit the explanation that this ascites tumour grows initially in fatty tissue and, when growth is sufficiently advanced, cells pass into the peritoneal cavity. If this is the mechanism of growth of this tumour, the hypothesis that the cells multiply actively while freely suspended in peritoneal fluid remains to be proved.

I am indebted to Dr. Franks, Banting Institute, Toronto, for the sarcoma 37 and to Hansi Kroeker and Miss Melville and staff for technical assistance. The work was supported by a grant from the National Cancer Institute of Canada.

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A Proprioceptor in the Body Musculature of Lepidoptera

DURING a study of muscle histolysis in saturniid moths[1], sense organs were found in association with the intersegmental muscles. So far as we can ascertain, they are of a type not previously described for insects. They resemble the receptors discovered by Alexandrowicz[2] in the Crustacea. Each receptor consists of a modified muscle fibre in which the striations are faint, but which is capable of contraction. In the final instar larva of *Antheraea pernyi*, there is a pair of these receptors in the meso- and meta-thorax and in abdominal segments 1–9. The receptors lie in the dorsal longitudinal muscles[1] and are attached to the epidermis at the intersegmental folds. They persist during metamorphosis and are present in the abdomen of the pupa and adult, but so far they have not been located in the thorax of these stages. Near the middle of the fibre, a swelling is formed by an ovoid sac filled with an unidentified substance which stains with some nuclear stains such as hæmatoxylin and celestin blue. Attached to the receptor at this point is a single large sensory neurone the dendrites of which enter a fibre tract running the full length of the receptor. The fibre tract appears to be composed of connective tissue fibres. A rich motor innervation is present, with nerve endings at intervals all along the organ. Similar receptors have been found in *Platysamia cecropia*, *Telea polyphemus*, *Samia walkeri* and *Actias selene*.

The function of the receptors of the pupa of *A. pernyi* has been investigated oscillographically. After exposure of a single receptor with a suitable length of nerve, a strip of cuticle bearing the receptor is removed from the pupa. Flaps of cuticle from the neighbouring segments are left at either end of the preparation. These flaps are clamped in an apparatus designed for stretching and relaxing the receptor. It consists of a 'Perspex' trough with a fixed clamp for one end of the cuticle strip and an adjustable clamp for the other end. The adjustable clamp is attached to a metal rod which can be locked when the preparation is in a suitable position. The bracket for the rod is in turn attached to a solenoid which causes the rod and clamp to flick to and fro in the direction of the longitudinal axis of the preparation. The amount of stretching and relaxation thus imposed on the receptor is controlled by micrometer screws. Throughout the experiments the preparation is immersed in insect Ringer's solution[3].

A regular single unit impulse discharge can be recorded from this preparation. The duration of impulse is approximately 5 msec. at room temperature, and the discharge frequency depends on the tension. Frequencies of about 30 impulses/sec. are commonly found when the preparation is set up with a minimum of tension. The discharge activity continues unaltered for an hour and longer. Stretching the preparation evokes an immediate increase in the discharge frequency, and the higher level of activity is maintained while the stretch lasts. There is a certain amount of adaptation; but the time course of the adaptation is very slow. After cessation of stretch, there is a marked post-stimulatory depression followed by a gradual return of the impulse activity to the initial discharge frequency.

The presence in insects of proprioceptor organs closely resembling both in structure and in mode of function[4] those recently discovered in Crustacea appears to be of considerable interest. A detailed study of the histological structure of the organ and of the quantitative aspects of its responses is in progress, and the results will be published elsewhere.

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Sodium Extrusion in Muscle

THE extrusion of sodium from the living cell against a concentration gradient has been demonstrated by Steinbach[1], Desmedt[2] and Maizels[3]. The mechanism of such an extrusion is often referred to as a 'sodium pump'. We have repeated the above experiment with nerve and muscle; but we find it difficult to obtain consistent results, because toad (*Bufo marinus*) tissue does not always lose potassium and gain sodium in the cold. This pump is not entirely activated by temperature change, as the above authors neglect to stress that extrusion of sodium does not take place unless the external potassium is increased above physiological level.

In the course of work on ionic equilibria[4,5], we had occasion to investigate the level to which the intracellular sodium would fall when the tissues were placed in Ringer solution of which half the sodium had been replaced by sucrose. A pair of muscles (or nerves) is allowed to equilibrate in normal Ringer solution for 2 hr. (longer for nerves), and then one member is analysed and the companion transferred to Ringer solution in which half the sodium has been replaced by sucrose. It is found that the intracellular sodium decreases to half that of the control. It will be apparent from a study of Fig. 1 that this sodium has been extruded against a chemical gradient. We have found that this 'pump' is extremely reliable when contrasted with the vagaries of the Steinbach pump.

A survey of the time relationships shows that the sodium extrusion may be complete (in small muscles) in as short a period as half an hour, usually within an hour, and no further ionic alteration takes place during the following three hours.

The 'pump' described differs in one particular respect from that of Steinbach in that the potassium-levels remain constant throughout the whole of the experiment, whereas according to Steinbach there is a concomitant pumping in of potassium when the

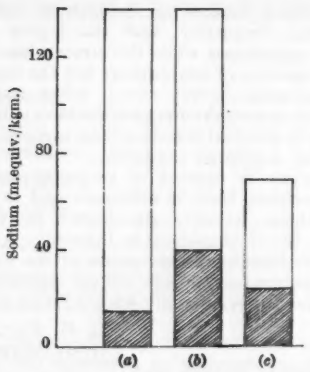

Fig. 1. (*a*) Muscle unsoaked (shaded) and in normal plasma (unshaded); (*b*) muscle soaked (shaded) and in normal Ringer (unshaded); (*c*) muscle soaked (shaded) and in half-sodium Ringer (unshaded).

Sodium content of muscle is calculated on an intracellular basis and on wet-weight. (The loss of sodium from muscle soaked in normal Ringer, when placed in half-sodium Ringer, is a loss against a concentration gradient)

cold muscles are warmed. Thus our experiment provides another example of the non-reciprocity of sodium and potassium movements (for other examples, see ref. 4).

The independence of the movements of sodium and potassium is further emphasized when we consider the action of metabolic inhibitors on the extrusion of sodium into the half-sodium Ringer solution.

The nature of the 'pump' has been investigated in the following manner:

Cold: the extrusion of sodium is entirely inhibited by reducing the temperature to 5° C.; but the potassium-level is unaffected.

Monoiodo acetic acid (1 m*M*): prevented extrusion of sodium and caused considerable loss of potassium. The tissues were bunched and failed to contract on stimulation.

Sodium fluoride: toad muscle appears to be resistant to the action of this inhibitor, but at high concentration (30 m*M*) the extrusion of sodium is inhibited without affecting the potassium-level.

Calcium lack: as the level of calcium will be reduced by sodium fluoride, the effect of calcium-free Ringer solution was tested. Extrusion of sodium was not inhibited and potassium remained constant.

2 : 4-Dinitrophenol: the extrusion of sodium is not inhibited by 2 : 4-dinitrophenol at a concentration of 10^{-3} *M*, although the muscles showed marked loss of potassium, and failed to contract on stimulation.

Azide: this inhibitor was also without effect on the extrusion, but at a concentration of 3 m*M* caused marked loss of potassium and bunching of the tissue.

Yohimbine: did not affect the extrusion of sodium or alter the potassium level; but at 5×10^{-4} *M* the muscles failed to respond to stimulation.

Cyanide (5 m*M*): did not affect the extrusion of sodium, or alter the potassium-level. The muscles contracted well on stimulation.

It would appear probable from this limited range of inhibitors that the energy for the extrusion of sodium is derived from the glycolytic part of the respiratory cycle.

There was no extra oxygen uptake by the muscle during the extrusion of sodium.

The resting and action potentials were followed by means of internal micro-electrodes. During the whole of the period there was little or no alteration in the resting potential (88 mV.). Within a few minutes of placing the muscle in the half-sodium solution the action potential fell from 132 mV. to 115 mV. There was no subsequent rise in action potential, although sodium was being extruded from the cell until the original gradient was restored, which is in contradistinction to the results of Desmedt[3].

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Adenosine Triphosphate in the Adrenal Medulla of the Cow

During investigations on the specific adrenal medullary granules containing adrenaline and noradrenaline[1], it was found that these structures have high contents of acid-labile phosphorus. In preliminary experiments with ion-exchange chromatography on 'Dowex 2' using formic and hydrochloric acid as eluting agents, a fraction was obtained in which the main part of the acid-labile phosphorus was recovered. Judging from the ultra-violet absorption and the ratio pentose : acid-labile phosphorus : total phosphorus, the chief compound in this fraction seemed to be adenosine triphosphate. Therefore the method of Cohn and Carter[2] for separation of adenosine phosphates was applied to adrenal medullary extracts.

The medulla of cow suprarenal glands, removed from the body 40–60 min. after killing the animals, was extracted with 10 per cent trichloroacetic acid in the cold. The barium and alcohol-insoluble phosphorus compounds were precipitated together by the method of LePage[3], dissolved in 0·1 *N* hydrochloric acid and the barium removed with sulphuric acid. The solution was brought to about *p*H 8·5 with ammonium hydroxide and the phosphorus compounds were adsorbed on a 'Dowex 2' column (200–400 mesh, chloride form, 40 mm. × 13 mm., flow-rate 0·5 ml./min.). They were eluted (flow-rate 1 ml./min.) according to the method of Cohn and Carter[2] (two experiments) or according to the modification of this method by Deutsch and Nilsson[4] (five experiments). Fractions of 25 ml. were collected, analysed for inorganic phosphorus, acid-labile phosphates, total phosphorus and pentose, and the ultra-violet absorption was measured. Phosphorus was determined by the method of Martin and Doty[5]. Acid-labile phosphorus was estimated after hydrolysis (8 min.) in 1 *N* hydrochloric acid at 100° C. Pentose estimations were carried out according to the method of Albaum and Umbreit[6]. Optical densities were measured in a Beckman spectrophotometer, Model *DU*, the molecular extinction coefficient of adenosine triphosphate at 257 mμ (14,200) being used.

Only 7–14 per cent of the acid-labile phosphorus (P_8 in Fig. 1) appeared in the fractions eluted with 0·01 *M* hydrochloric acid – 0·02 *M* sodium chloride and with 0·01 *M* hydrochloric acid – 0·05 *M* sodium chloride. The remaining part (86–93 per cent of the

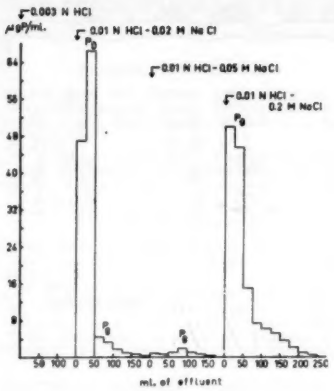

Fig. 1

total acid-labile phosphorus of the barium and alcohol-insoluble phosphorus compounds) was eluted with 0·01 *M* hydrochloric acid – 0·2 *M* sodium chloride (Fig. 1). The ultra-violet absorption and the molar ratios pentose : acid-labile phosphorus : total phosphorus of these latter fractions indicated that the eluted compound was adenosine triphosphate. The identity and purity of the preparations were checked after isolating them as the barium salt from pooled fractions and converting the salt to the free acid with 'Dowex 50' (hydrogen form) by paper chromatography and by counter-current distribution analyses.

R_P values, identical with those of adenosine triphosphate isolated from rabbit muscle, were obtained by two-dimensional paper chromatography according to Deutsch and Nilsson[7].

Craig counter-current distributions were carried out with 11 ml. of each phase per tube in system 6 used by Plaut, Kuby and Lardy[8] for separation of phosphoric esters by solvent partition.

It would appear from Fig. 2 that the experimental curves, calculated from pentose and ultra-violet absorption, agree well with the theoretical ones.

Moreover, the calculated partition coefficient is in close agreement with that obtained for adenosine triphosphate isolated from rabbit muscle. The partition coefficients obtained under our experimental conditions (10·1) have been compared with those reported by Plaut, Kuby and Lardy[8] (15), and the difference seems not to lie beyond the limits of error.

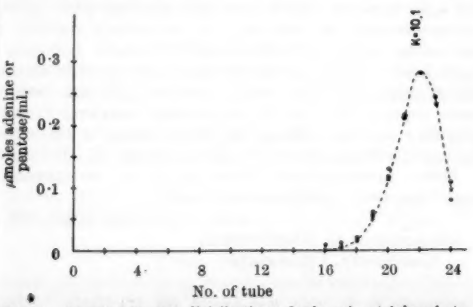

Fig. 2. Counter-current distribution of adenosine triphosphate from cow adrenal medulla in the system hexanol, octadecylamine/water (*p*H 7·05): ●, pentose; ○, ultra-violet absorption (optical density at 257 mμ); × – – ×, theoretical curve for $K = 10·1$

In the seven experiments, the following amounts of adenosine triphosphate were found, calculated on the basis of the phosphorus contents: 520, 445, 585, 500, 420, 595 and 400 mgm. (free acid) per 100 gm. wet weight of cow medulla. Preliminary experiments show that practically all the adenosine triphosphate is localized to the particular granules containing adrenaline and noradrenaline in the cytoplasm of the medullary cell, and that no appreciable breakdown occurs during several days in granules isolated and suspended in 0·3 *M* sucrose and kept at 4° C.

The large amounts of adenosine triphosphate and its stability in the cow suprarenal medulla suggest that this tissue may be a suitable source for large-scale preparation of this substance.

The investigation has been supported by a grant from Statens Medicinska Forskningsråd.

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Filterability of the Swarmers of *Rhizobium* and *Azotobacter*

ALTHOUGH the existence of tiny, motile swarmers as a stage in the life-cycles of the nitrogen-fixing bacteria, *Rhizobium* and *Azotobacter*, has been known for many years, recent authoritative reviews[1] have cast doubt upon the genuineness of the phenomenon.

The ability of the swarmers of *Rhizobium* to pass through a Chamberland candle has been recorded[2]; but those of *Azotobacter* are not known to have been filtered successfully[3].

In the course of some observations upon the life-cycles of these bacteria, the swarmers of both genera have been separated from the vegetative cells by filtration, and from the filtrate new cultures have successfully been made. This offers conclusive proof of the validity of the complex life-cycle in both cases.

It appears that much of the previous work in this field has been carried out without consideration of the size of the filter-pores or that of the gonidia to be filtered. Microscopic examination showed that the size of the gonidia was about a quarter of the width of the vegetative cell, that is, 0·3 micron in the case of *Rhizobium* gonidia and 0·8 micron with *Azotobacter*. 'Sinterware' sintered glass filters were employed. These were cleaned with concentrated nitric acid each time they were used; then, after washing well with water, the filter, filter flask and a container for the filtrate inside the filter flask were autoclaved before use.

Cultures were grown on potato agar and the growth emulsified with Ringer's solution. A coarse filter (No. 2) was first employed in order to remove the large aggregates of particles. A manometer and an air-leak were fitted to the pump so that the pressure could be controlled at – 500 mm.

With *Rhizobium* cultures a No. 5 filter was used. This has a pore size of one micron and will pass particles up to 0·3 micron. Results were rather variable; sometimes it was possible to filter the gonidial stage, at other times it was not, although microscopic examination showed that gonidia were being produced. These variations may possibly be due to the close size of the swarmers and the filter pores.

In the case of *Azotobacter*, consistent results were obtained with a No. 4 filter, which will pass particles less than 3 microns in diameter. Young cultures were used as controls. These were examined microscopically to ascertain that they were not producing gonidia. It was found that filtrates from these cultures contained no viable cells, whereas filtrates from the gonidia-producing cells gave a heavy growth on subculture. By centrifuging the filtrates and examining microscopically, it could be shown that no vegetative cells had passed through the filter.

Failure in the past to filter *Azotobacter* gonidia would appear to be due to workers using filters that were too fine; de Regel[3], for example, used filters with a pore size of 0 75 micron. This would certainly not allow the passage of *Azotobacter* gonidia.

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Erosion in Meanders

Secondary flows are developed when a non-uniform stream passes through a bend, the plane of which contains the vorticity vector of the entry flow[1]. The importance of such secondary velocities in the erosion of river meanders was pointed out originally by Thompson[2], and large transverse secondary velocities have been observed in the flow of air through pipe bends, at Cambridge and elsewhere[3].

Experiments have been conducted in Cambridge on a water flume to investigate the rate of erosion in meanders of different amplitude. The cross-section of the channel at the beginning of each of these experiments was an equilateral triangle of side 4 in., and the water velocity was 6–8 in. per sec. during the experiments. A standard mixture of sand and aluminous cement was used to form the meanders.

Fig. 1 shows the shape of the meanders in the first experiment, and the nature of the erosion observed.

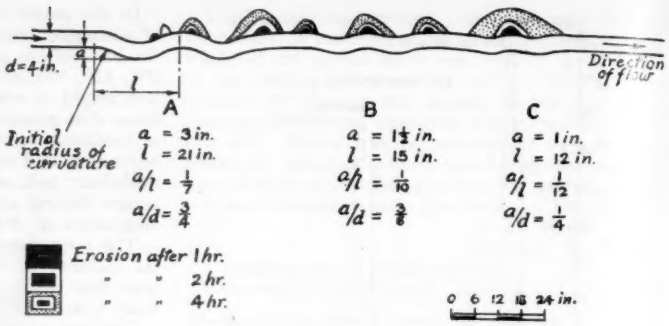

Fig. 1

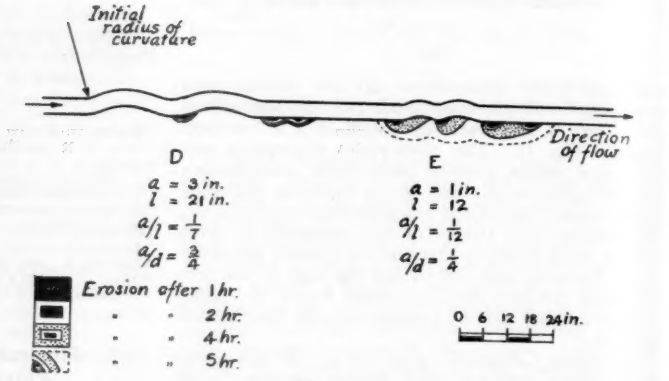

Fig. 2

The rate of erosion was greatest for the smallest meander (*C*) and least in the largest meander (*A*). The walls of the channel were eroded on the outside of the meander bends; but almost all the erosion was confined to one wall of the channel, namely, the wall on the outside of the initial bend curvature. The high-velocity water near the surface would be displaced towards this wall by secondary motion in the initial bend[3].

In a second experiment, the initial curvature of each meander was reversed, and the direction of any secondary rotation therefore also reversed. Fig. 2 shows the development of the meanders and indicates that erosion was now completely confined to the other side of the channel; that is, once again the side towards which the high-velocity part of the stream should be diverted by secondary motion in the initial bend. A longer settling length between a large and a small meander was used in this second experiment; but the small meander (*E*) was eroded more rapidly once more, the erosion starting in each meander on the outside of those bends of the same radius of curvature as the initial radius of curvature.

These investigations were made in co-operation with the Ouse Catchment Board.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 28

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Theatre of the Science Museum, South Kensington, London, S.W.7), at 5.30 p.m.—Mr. Frank Greenaway: "Models of Molecules—Some Historical Observations".

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. K. Wilson-Jones: "The Control of Parasitic Weeds".

Tuesday, November 29

UNIVERSITY OF LONDON (at Bedford College, Regent's Park, London, N.W.1), at 4.30 p.m.—Dr. W. J. L. Sladen: "Biological Research in the Antarctic" (Stevenson Lecture).*

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT SECTION (joint meeting with the RADIO SECTION, at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. C. J. N. Candy: "The Specification of the Properties of the Thermistor as a Circuit Element in Very-Low-Frequency Systems" and "A Vector Method for Amplitude-Modulated Signals".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at the Sir John Cass College, Jewry Street, London, E.C.3), at 6.30 p.m.—Dr. A. J. P. Martin, F.R.S.: "Gas–Liquid Chromatograph".

INSTITUTION OF MECHANICAL ENGINEERS, EDUCATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Laboratory Work—Purpose and Methods".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. F. B. Greatrex: "The Noise of Jet Engines".

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, Portland Place, London, W.1), at 7 p.m.—Mr. A. St. Johnston: "Electronic Computing Methods".

SOCIETY FOR ANALYTICAL CHEMISTRY (in the Beveridge Hall, University of London, Senate House, London, W.C.1), at 7.30 p.m.—Prof. J. Heyrovský (Prague): "The Development of Polarographic Analysis".

Wednesday, November 30

BRITISH NUCLEAR ENERGY CONFERENCE (joint meeting of the INSTITUTION OF CIVIL ENGINEERS, the INSTITUTION OF MECHANICAL ENGINEERS, the INSTITUTION OF ELECTRICAL ENGINEERS, the INSTITUTE OF PHYSICS and the INSTITUTION OF CHEMICAL ENGINEERS, at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 2.15 p.m.—Inaugural Meeting. Sir Christopher Hinton, F.R.S.: Opening Address; Sir John Cockcroft, F.R.S.: "The United Kingdom Atomic Energy Project"; Mr. V. A. Pask and Mr. J. C. Duckworth: "The Place of Nuclear Energy in United Kingdom Power Development"; Mr. H. J. Grout: "The Use of Research Reactors in Nuclear Power Development"; Mr. A. S. Maclean and Dr. W. H. Marley: "Health and Safety in a Nuclear Power Industry".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Anniversary Meeting.

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. L. C. Nickolls: "Scientific Aspects of the Detection of Crime".

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. H. J. Leak: "High Fidelity Loudspeakers—the Performance of Moving-Coil and Electrostatic Transducers".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the SOUTH-WEST ESSEX TECHNICAL COLLEGE CHEMICAL SOCIETY, at the South-West Technical College, Forest Road, Walthamstow, London, E.17), at 7 p.m.—Dr. R. N. Haszeldine: "Fluorocarbons and their Future".

SOCIETY FOR ANALYTICAL CHEMISTRY (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Mr. A. A. Smales: "Atomic Energy and the Analyst".

Thursday, December 1

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Lieut.-Cdr. F. R. J. Spearman, Mr. J. J. Gait, Mr. A. V. Hemingway and Mr. R. W. Hynes: "TRIDAC—a Large Analogue Computing Machine".

ROYAL AERONAUTICAL SOCIETY (in the Main Dining Hall, Airmen's Mess, A. and A.E.E., Boscombe Down), at 6.30 p.m.—Mr. P. A. Hufton: "Free Flight Techniques for High Speed Aerodynamic Research".

CHEMICAL SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 7.30 p.m.—Dr. E. W. R. Steacie, F.R.S.: "Reactions of Radicals in Gaseous Systems" (Liveridge Lecture).

Friday, December 2

UNIVERSITY OF LONDON (at Charing Cross Hospital Medical School, Chandos Place, London, W.C.2), at 5 p.m.—Dr. R. K. Burns (Carnegie Institution of Washington): "Experimental Studies of Sex Differentiation in the Opossum".*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5 p.m.—Mr. E. J. H. Corner: "Botanical Collecting with Monkeys".

Saturday, December 3

BRITISH INTERPLANETARY SOCIETY (in the York Hall, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Mr. E. Burgess; "Probing Interplanetary Space".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT (Grade B) IN PHYSICS—The Registrar, Nottingham and District Technical College, Shakespeare Street, Nottingham (November 30).

ASSISTANT LECTURER (with a good honours degree or Associateship of the Royal Institute of Chemistry, and research and/or industrial experience) IN CHEMISTRY, at the Technical College of Monmouthshire, Crumlin—The Director of Education, County Hall, Newport, Mon. (November 30).

BIOCHEMIST, Scientific Officer grade, for research work on the organic chemistry of the hop plant—The Registrar, Wye College, near Ashford, Kent (November 30).

COMPUTER (with an ordinary pass degree in mathematics or equivalent qualification) IN THE DEPARTMENT OF PHYSICS, for work in connexion with a programme of research on the crystal structure of organic compounds—Joint Clerk to the University Court, Queen's College, Dundee (November 30).

RESEARCH FELLOW (with research experience, preferably on natural products) IN CHEMISTRY, at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1 (November 30).

AREA CHIEF SCIENTIST (preferably with a good honours degree, with considerable experience of industrial science, fuel technology and laboratory administration)—The Staff Director, National Coal Board, East Midlands Division, Sherwood Lodge, Arnold, Notts, quoting S.V.467 (December 3).

LECTURER or ASSISTANT, Grade B (with special interests in inorganic chemistry, high academic qualifications with good teaching and/or research experience), IN THE DEPARTMENT OF CHEMISTRY—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3 (December 3).

LIBRARIAN (with a scientific background, preferably with a pass degree or equivalent, and proficient in German) for a small but specialized library—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford, Herts (December 8).

ASSISTANT LECTURER or LECTURER IN PHYSICS—The Registrar, The University, Sheffield (December 10).

RESEARCH ASSISTANT (with a first-class or good second-class honours degree in chemistry) IN THE COAL CONSTITUTION LABORATORY of the Department of Mining, to be a member of a team carrying out research on the chemical constitution of coal, including the examination of the products of mild oxidative degradation of coal—The Professor of Mining, The University, Edgbaston, Birmingham 15 (December 12).

SENIOR LECTURER and LECTURERS (2) IN THE DEPARTMENT OF BOTANY, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 12).

LECTURER IN PHYSIOLOGY, at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1 (December 15).

PROFESSOR OF MARINE ENGINEERING; PROFESSOR OF HYDRAULIC MACHINES; PROFESSOR OF TEXTILE ENGINEERING; and a PROFESSOR IN PRODUCTION OF ARMAMENTS AND AMMUNITIONS—The Dean, Faculty of Engineering, Alexandria University, Alexandria, Egypt (December 17).

RESEARCH STUDENT (with a good honours degree in chemistry) IN CHEMISTRY—The Registrar, University College of North Staffordshire, Keele, Staffs (December 17).

LECTURER/SENIOR LECTURER (preferably with experience in endocrine or reproductive physiology) IN VETERINARY PHYSIOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 19).

LECTURER (with special qualifications in hydraulics) IN THE DEPARTMENT OF FLUID MECHANICS—The Registrar, The University, Liverpool (December 19).

LECTURER (with special interest in the fields of low temperature and solid state physics) IN THEORETICAL PHYSICS, in St. Salvator's College—Joint Clerk to the University Court, The University, St. Andrews (December 31).

RESEARCH ASSISTANT IN AERONAUTICS—The Secretary of University Court, The University, Glasgow (December 31).

SENIOR LECTURER IN CIVIL ENGINEERING, at Kumasi College of Technology, Gold Coast—The Secretary, Advisory Committee on Colonial Colleges, 1 Gordon Square, London, W.C.1 (December 31).

IMPERIAL CHEMICAL INDUSTRIES FELLOWS (3) for research in chemistry, physics and allied subjects, including the biological application of chemistry—The Registrar, University Office, 46 North Bailey, Durham (January 9).

STAFF TUTOR (with qualifications in and, if possible, experience of extra-mural teaching in zoology and/or botany with particular reference to the promotion of field studies among adult students) IN NATURAL HISTORY in the Department of Extra-Mural Studies—The Secretary, Queen's University, Belfast (January 16).

ASSISTANT LECTURER (Grade A) IN THE DEPARTMENT OF CHEMISTRY AND BIOLOGY, College of Technology and Commerce, Cardiff—The Director of Education, City Hall, Cardiff.

ASSISTANT LECTURER (with an honours degree in chemistry and able to teach one branch of chemistry up to B.Sc. special chemistry degree standard, and preferably with industrial experience) IN THE SCHOOL OF CHEMISTRY—The Registrar, College of Technology and Commerce, The Newarke, Leicester.

BIOCHEMIST (with a first- or second-class honours degree in biochemistry or equivalent qualification, and with postgraduate research

experience) to assist in the study of certain physico-chemical properties of mucin, initially for a period of two years—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting 55/20.

Bradford Dyers' Association Limited Research Fellow (with high qualifications in science) to undertake research in tinctorial chemistry, textile chemistry or an allied subject—The Principal, Technical College, Bradford.

Chemist or Biochemist (with an honours degree) in the Serum Department, for the routine control of therapeutic sera and research on biochemical and biophysical problems in the field of serum proteins—The Secretary, The Lister Institute, Elstree, Herts.

Engineers and Physicists, Senior Scientific and Scientific Officer grade (with an appropriate first- or second-class honours degree or equivalent high professional attainments) in Royal Naval Scientific Service Experimental Establishments, chiefly in the Weymouth and Portsmouth areas and Home Counties—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.344/5A.

Hospital Physicist (Senior grade), to serve the Radiotherapy Departments of the General Hospital, Southend-on-Sea, and the Essex County Hospital, Colchester, in association with the Physics Department of the London Hospital—The Secretary, Southend-on-Sea Hospital Management Committee, General Hospital, Southend-on-Sea.

Mathematical Consultant (with a mathematical or science degree, and preferably with experience of electrical computing machines) in the Engineering Research Department for work consisting of computation and mathematical analysis of problems relating to all branches of audio and radio frequency and television engineering—Engineering Establishment Officer, Broadcasting House, London, W.1, quoting E.315.N.

Physicists, Scientific Officer class and Experimental Officer class, at Ministry of Supply Research and Development Establishments, chiefly near Farnborough, Hants; Malvern, Worcs; Salisbury, Wilts; and Sevenoaks, Kent; for work on guided weapons, rockets, gas turbines, aerodynamics, aircraft structures and equipment, armaments, instrumentation including optics, and electronics—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.398/5A.

Principal Scientific Officer or Senior Scientific Officer (with a first- or second-class honours degree or equivalent, and at least three years postgraduate research experience, and a good basic knowledge of radio engineering and experience in the development of telecommunications apparatus) at the Ministry of Supply Headquarters, London, for work associated with the development of field and fixed radio equipment, television, counter measures, telemetry, vehicle installations, and radio navigation—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.520/5A.

Psychologist in the Research Department—The Secretary, Royal Eastern Counties Hospital, Abbeygate House, Colchester, Essex.

Research Assistants for research on the chemical physics of polynuclear aromatic compounds, and on the melting mechanisms of ionic crystals—Prof. A. R. Ubbelohde, Imperial College, London, S.W.7.

Research Fellow (with a degree in electrical engineering or in physics) in the Engineering Laboratory, University of Oxford, to work under the direction of the Donald Pollock Reader, Dr. H. Motz, on problems of millimeter wave generation—Prof. A. Thom, Engineering Laboratory, 19 Parks Road, Oxford.

Research Worker (with a veterinary qualification or a good honours degree in a biological subject, and preferably with experience in microbiology and/or histology), to study problems associated with virus infections of animals; and a Research Worker (with an honours degree in a biological subject and an interest in ecology) for original research on parasitic worms of livestock—The Secretary, Animal Diseases Research Association, Gilmerton, Edinburgh 9.

Senior Scientific Officers (with a first- or second-class honours degree or equivalent in physics or engineering, and preferably with a knowledge of aircraft or aircraft systems) at a Ministry of Supply Experimental Establishment, near Amesbury, Wilts, for planning and development of special trials of aircraft guided weapon systems—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.410/5A.

Senior Technician in Zoology—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1.

Technical Editor (with a degree in engineering, metallurgy or science, experience of technical editing, and familiarity with welding terms)—The Secretary, Institute of Welding, 2 Buckingham Palace Gardens, London, S.W.1.

Theoretical Physicist (with a first- or second-class honours degree in physics, and at least three years postgraduate research experience, preferably in the field of motion and coagulation of particulate suspensions) to work on problems of size distribution in coagulating and dispersing particulate suspension—The Senior Recruitment Officer, United Kingdom Atomic Energy Authority, Aldermaston, Berks, quoting 726/2.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Foot-Rot of Sheep—Stamp It Out. By Prof. W. I. B. Beveridge. Pp. 11. (London: Universities Federation for Animal Welfare, 1955.) [29

Crypton News. Vol. 1, No. 1 (August, 1955). Pp. 7. (Bridgwater, Somerset: Crypton Equipment, Ltd., 1955.) [29

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 660, Vol. 239 (30 August, 1955): Spirodistichy Re-interpreted. By Mary Snow. Pp. 45–88. (London: Royal Society, 1955.) 15*s*. 6*d*. [29

Proceedings of the Royal Irish Academy. Vol. 57, Section A, No. 3: Note on the *Tamm-Dancoff* Method. By E. Arnous. Pp. 31–36. 1*s*. Vol. 57, Section A, No. 4: The Application of Certain Linear Quaternion Functions of Quaternions to Tensor Analysis. By C. W. Kilmister. Pp 37–52. 2*s*. 6*d*. Vol. 57, Section B, No. 5: The Precipitation of Serum Proteins by Branched-Chain Paraffinic Compounds. Part 1: The Precipitation of Serum Proteins by certain Branched-Chain Antitubercular Compounds and Its Relation to the in Vitro Inhibition of these Compounds by Human Serum. By W. M. D. Armstrong. Pp. 55–70. 1*s*. Vol. 57, Section B, No. 6: The Old Red Sandstone of the Kerry Head Anticline, County Kerry. By M. F. H. Khan. Pp. 71–78. 1*s*. Vol. 57, Section B, No. 7: The Tertiary Lava Succession in the Northern Part of the Antrim Plateau. By E. M. Patterson. Pp. 79–122 +5 plates. 7*s*. 6*d*. Vol. 57, Section B, No. 8: *Amphilochus Brunneus* Della Valle, an Amphipod New to Britain and Ireland, and Notes on other Amphipods not previously recorded in Irish Coastal Waters. By Margaret Duhig and Carmel Humphries. Pp. 123–130. 1*s*. Vol. 57, Section B, No. 9: Genus *Paraphyllopodopsyllus* Lang (Copepoda Harp). By Katherine M. Roe. Pp. 131–139. 1*s*. 6*d*. (Dublin: Hodges, Figgis and Co., Ltd., 1955.) [59

National Oceanographic Council. Proceedings of the Commonwealth Oceanographic Conference, 18–22 October, 1954, held at the National Institute of Oceanography, Wormley, Surrey. Pp. v+93. (Cambridge: At the University Press, 1955.) 7*s*. net. [59

Other Countries

International Scientific Radio Union. Proceedings of the 11th General Assembly held in The Hague from August 23rd to September 2nd, 1954. Vol. 10, Part 4: Commission 4—On Radio Noise of Terrestrial Origin. Pp. 60. (Brussels: International Scientific Radio Union, 1955.) 60 Belgian francs; 8*s*. 8*d*.; 1.20 dollars. [298

International Council of Scientific Unions. Mixed Commission on the Ionosphere. Proceedings of the Fourth Meeting, held in Brussels, from August 16th to 18th, 1954. Pp. 238. (Brussels: International Scientific Radio Union, 1955.) 300 Belgian francs; 43*s*.; 6 dollars. [298

Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for the year ended 31st December, 1954. Pp. 12. (Sydney: Museum of Applied Arts and Sciences, 1955.) [298

State of California. Department of Fish and Game: Marine Fisheries Branch. Fish Bulletin No. 99: A Description of Two Species of Bonito *Sarda Orientalis* and *S. Chiliensis*, and a Consideration of Relationships Within the Genus. By H. C. Godsil. Pp. 43. Fish Bulletin No. 100: Catch Localities for Pacific Albacore (*Thunnus germo*) Landed in California, 1951 through 1953. By Harold B. Clemens. Pp. 28. Fish Bulletin No. 101: Age Determination of the Northern Anchovy, *Engraulis mordax*. Pp. 66. (Sacramento, Calif.: Printing Division, Documents Section, 1955.) [298

Annual Report of the Calcutta School of Tropical Medicine and the Carmichael Hospital for Tropical Diseases, 1953. Pp. ii+147. (Calcutta: Calcutta School of Tropical Medicine, 1955.) [298

Indian Forest Bulletin (New Series). No. 195: Cellulose and Paper—Indigenous Cellulosic Raw Materials for the Production of Pulp, Paper and Board. Part 25: Wrapping Papers from *Acacia decurrens* Willd. (Wattle Wood). By R. V. Bhat and H. K. Kaushik. Pp. ii+10. (Delhi: Manager of Publications, 1955.) As. -/14/-; 1*s*. 3*d*. [298

Forest Research Institute and Colleges, Dehra Dun. Pp. 28. (Dehra Dun: Forest Research Institute and Colleges, 1954.) [298

State of Illinois. Department of Registration and Education: Natural History Survey Division. Biological Notes No. 35: An Evaluation of the Red Fox. By Thomas G. Scott. Pp. 16. (Urbana, Ill.: Department of Registration and Education—Natural History Survey Division, 1955.) [298

United States Naval Observatory. Circular No. 59: Solar Eclipses, 1960–1963. By Simone Daro Gossner. Pp. 8. (Washington, D.C.: United States Naval Observatory, 1955.) [298

Smithsonian Miscellaneous Collections. Vol. 128, No. 5: Revision of Some Recent Foraminiferal Genera. By Alfred R. Loeblich, Jr., and Helen Tappan. Pp. i+37+4 plates. (Publication 4214.) (Washington, D.C.: Smithsonian Institution, 1955.) [308

Colony of Singapore. Annual Report of the Botanic Gardens Department for 1954. Pp. i+11+4 plates. (Singapore: Government Publications Bureau, 1955.) 50 cents. [308

World Health Organization. Technical Report Series No. 97: Joint FAO/WHO Expert Committee on Nutrition. Fourth Report. Pp. 58. (Geneva: World Health Organization; London: H.M. Stationery Office, 1955.) 2 Swiss francs; 3*s*. 6*d*. net, 0.60 dollars. [29

Report of the All-India Institute of Hygiene and Public Health, Calcutta, 1951–53. Pp. iii+83. (Calcutta: Government of India Press, 1955). [29

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Rapport Annuel pour l'Exercice 1954. Pp. 492. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1955.) 160 francs. [29

Geological Survey of Nigeria. Bulletin No. 24: The Nigerian Coalfield—The Geology of Parts of Oritsha, Owerri and Benue Provinces. Pp. viii+85+5 plates. (Kaduna Junction: Geological Survey, 1954.) 10*s*. 6*d*. [29

Companhia de Diamantes de Angola (Diamang). Services Culturais. Dundo–Lunda–Angola. Museu do Dundo. Publicacoes Culturais No. 26: Psocoptères de l'Angola. Par A. Badonnel. Pp. 266. (Lisboa: Companhia de Diamantes de Angola, 1955.) [29

List of Scientific Papers published in the Middle East. (Afghanistan, Cyprus, Egypt, Iran, Iraq, Israel, Lebanon, Pakistan, Sudan, Syria and Turkey.) No. 11 (February, 1955). Pp. i+84. (Cairo: UNESCO Science Cooperation Office, 1955.) [59

Thirty-Eighth Annual Report of the National Research Council of Canada, 1954–55, including the Annual Report of Canadian Patents and Development Limited. (N.R.C. No. 3607.) Pp. 44. (Ottawa: National Research Council, 1955.) [59

Indian Agricultural Research Institute. Pp. 80. Souvenir—Golden Jubilee, 1905–1955. Pp. 92. (New Delhi: Indian Agricultural Research Institute, 1955.) [59

Calendar of the New South Wales University of Technology, 1955. Pp. 412. (Sydney: New South Wales University of Technology, 1955.) [59